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Nuts & Volts

May 2005
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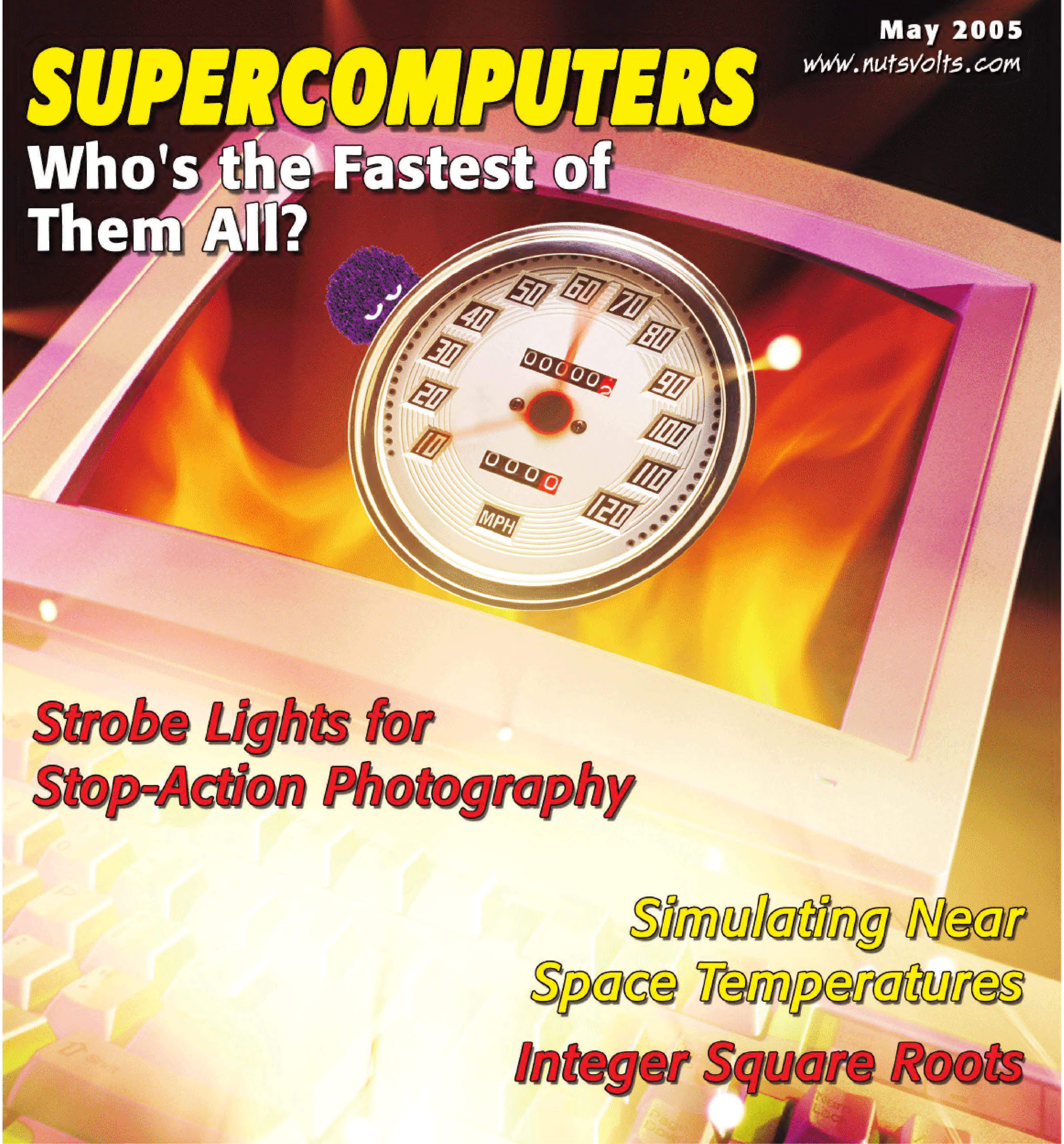

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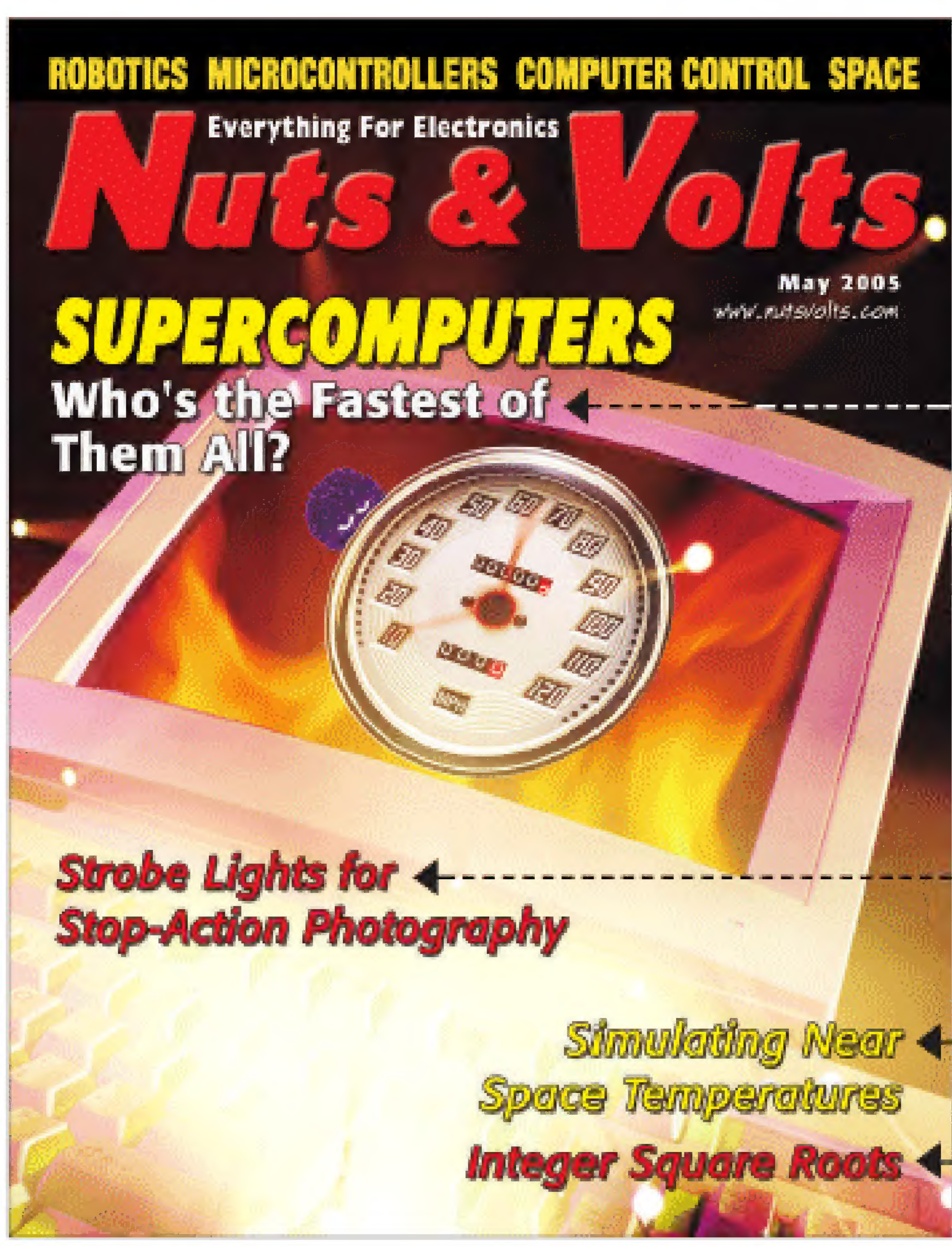

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DEPARTMENTS

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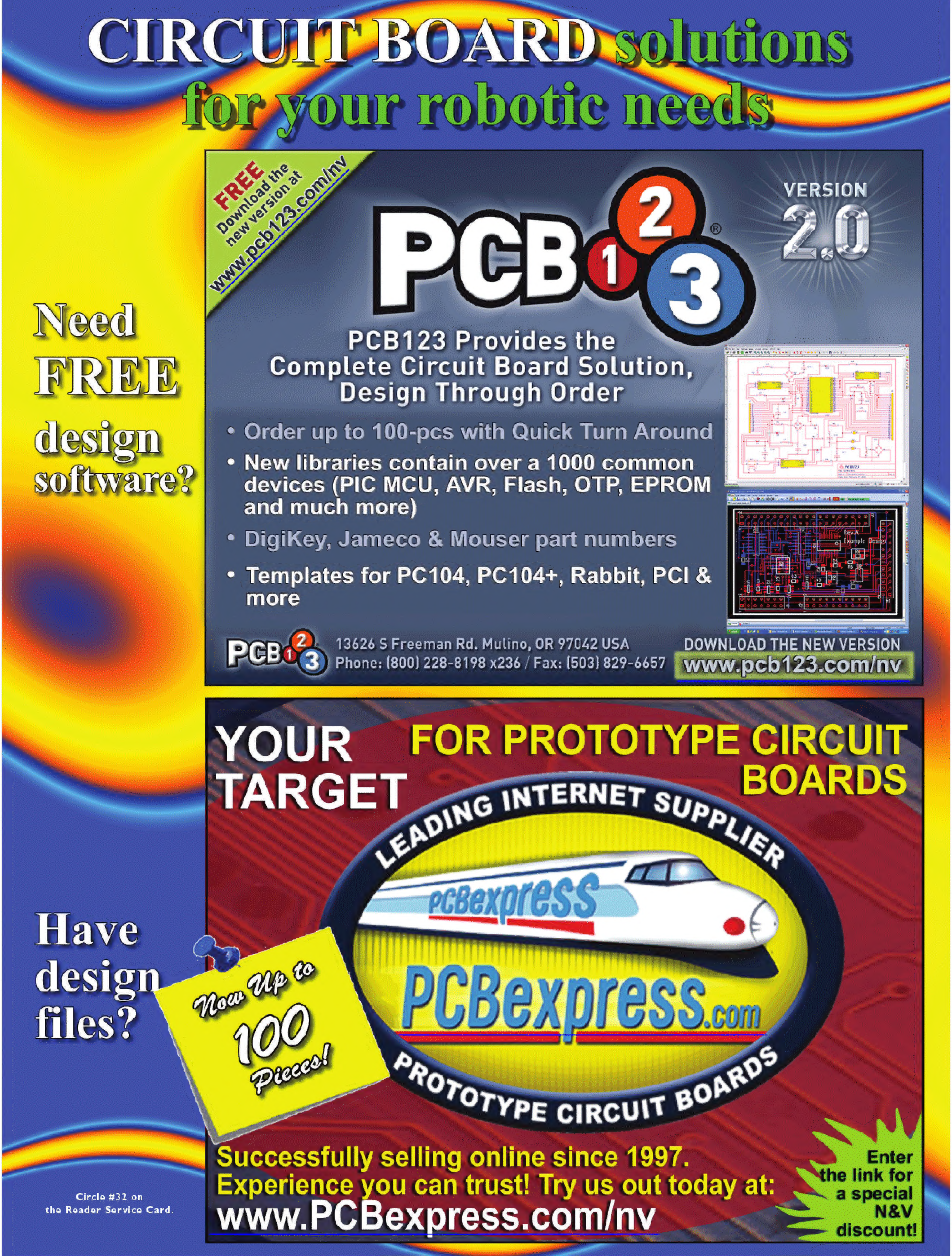
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Reader Feedback

Dear Nuts & Volts:

Please keep me informed as to the availability of a digital version of the magazine, either web- or CD-based. I am most interested in this as an addition to the print version, since it would make retrieval of items much easier. I would still like to receive the magazine in paper form as I like to be able to read it wherever I happen to be and I find a hard copy much easier to read on the move. Please keep up the good work — this is an incredibly good publication!

Phil Eldridge
via Internet

*Well, Phil, you're in luck! Beginning this very month, we'll have digital subscriptions available. Plus, we will also have a CD-ROM archive containing all of calendar year 2004's issues that can be searched, printed, and easily stored. For all the details, see Page 102 or go to **www.nutsvolts.com** and order! The CDs should be ready to ship about May 15th!*

Dear Nuts & Volts:

You have a great magazine. I love your question and answer columns. I also like that you have covered a wide range of subjects including statistics, project management, and basic electronics. Keep up the variety, but still mostly to the electronics. It would be great if you would provide a printed circuit source with your construction articles. I see that you have companies advertising in the magazine that do small quanties at a reasonable price. I would think that they would be glad to be a source.

Richard Lambert
via Internet

Dear Nuts & Volts:

In your March 05 issue, there was a project called Build a Geiger Counter — Part 1. I thought I might try to build the circuit, but wanted to wait for Part 2, which was supposed to be in the next issue (April). Did we forget?

Tom Gross
via Internet

Uh yeah ... try Page 50 in this issue.

Dear Nuts & Volts:

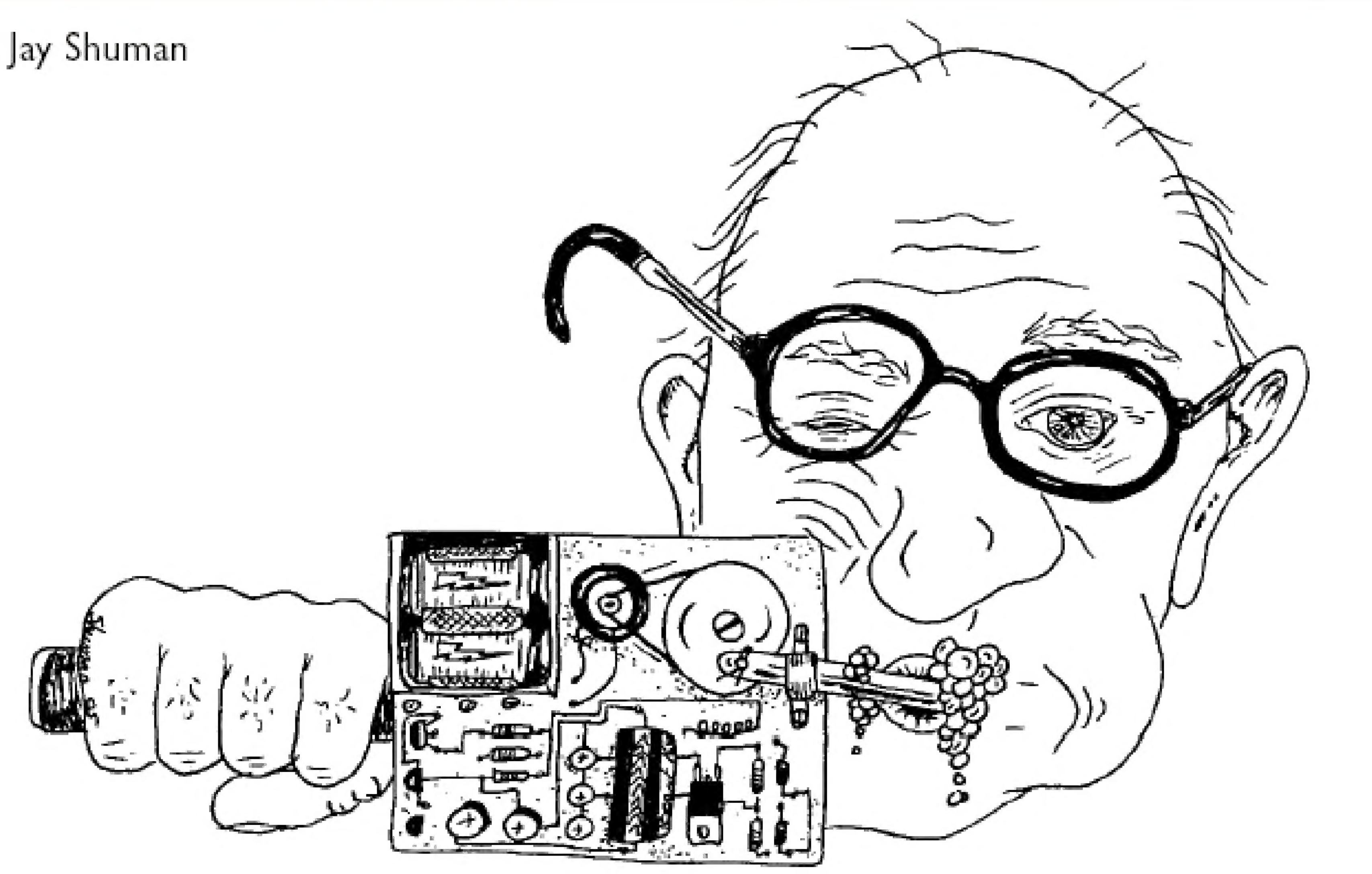
The April Fool issue has a good article about building a pulse generator, but with no parts list. You get to guess what parts the author is including in his schematic. Nice trick.

Albert McGarvey
via Internet

*A copy of the missing parts list is available at **www.nutsvolts.com**. Click on the April issue. (Ain't the web great!)*

Continued on Page 83

by Jay Shuman



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Events, Advances, and News From the Electronics World

If you see anything revolutionary and interesting — or just plain cool — while surfing newsgroups, filtering press releases, or simply doing your job, drop me a line about it. Have questions or comments about what you read here in "Techknowledgey 2005?" Send those my way, too. You can reach me at www.jkeckert.com
— *Jeff Eckert*

Advanced Technologies

Imaging Technique Improves Bone Grafts

This microcomputed tomography image provides a detailed look at both the vascularization and mineralization of a bone sample. Photo courtesy of Georgia Institute of Technology.

Researchers at Georgia Tech (**www.gatech.edu**) have come up with an imaging technique, called microcomputed tomography (micro-CT). It is said to provide one million times more detail than a traditional CT scan, and it was used recently in a program to develop bone graft substitutes that combine the best features of allografts (bone grafts taken from a donor) and autografts (grafts taken from the patient).

The technique can simultaneously look at both vascularization (the process in which blood vessels invade body tissues during the healing process) and mineralization (by which mineral crystals harden to regenerate bone) by generating three-dimensional images of the graft, thus allowing tissue engineers to provide the best possible implant design.

According to project head Dr. Robert Guldberg, "We're applying three-dimensional imaging techniques to quantify vascularization and mineralization in order to evaluate which of these tissue engineering approaches is going to be able to best and most quickly restore bone function. We've always known that vascularization is very important to bone repair, but we've never really had a good method to measure the process."

Guldberg's team has used micro-CT imaging to study fracture healing and repair of large bone defects that can result from the removal of bone tumors or from crushing injuries. Large bone defects are typically repaired with allografts, because large structural pieces are available from human donors. But allografts must be sterilized to avoid transmitting disease from donor to patient, so they are made up of dead material that may not heal well and can break up within a year.

Live grafts work better, but they have to be taken from elsewhere in the patient. A promising compromise is to wrap allografts with a biomaterial that contains live marrow cells or to employ bioactive genes which can result in accelerated repair and integration of the implants. In addition to studying bone regeneration, the ability to look at detailed three-dimensional images of vascular networks can shed light on research into vascular injuries and disc degeneration in the back, and it can facilitate early tumor detection by pinpointing areas of increased vascularization (which often indicate tumor growth).

Fuel Cell Uses Hydrogen Fuel

Nippon Telegraph and Telephone Corporation (**www.ntt.co.jp/index_e.html**) has developed a prototype miniaturized polymer-electrolyte fuel cell (PEFC) that uses hydrogen gas as a fuel and is small enough to fit in a mobile phone. Under tests using a production-model mobile phone, the prototype successfully powered start-up and signal reception/transmission (i.e., video phone, voice calls, and "i-mode" Internet services). In association with this development, NTT has also developed a device for automatically topping off the micro PEFC with hydrogen.

At present, the mainstream technology for mobile phone use is the direct-methanol fuel cell (DMFC), which uses methanol as the hydrogen fuel supply. However, a DMFC suffers from key disadvantages in that carbon dioxide is produced during power generation and, because of an insufficient power density per unit area, battery miniaturization is difficult.

According to NTT, the new PEFC attains an output power comparable to that of a lithium-ion battery without

producing any carbon dioxide during power generation. It is further believed to be adaptable to a wide variety of mobile devices, including camcorders, digital cameras, PDAs, and notebook PCs. NTT representatives did not speculate as to when the prototype will be ready for commercial production.

Computers and Networking

Rent a Supercomputer

IBM (**www.ibm.com**) recently announced a program that allows customers to access the renowned Blue Gene supercomputing system (see Page **XX** for information about the Blue Gene), located in Rochester, MN, on an hourly basis via a secure dedicated virtual private network. Called "Deep Computing on Demand," the program is expected to serve a number of markets in which the potential for achieving breakthroughs is great but the capital for purchasing a supercomputing system simply isn't available. These include drug discovery and product design, simulation and animation, financial, and weather modeling, among others.

The system allows customers to obtain a peak performance of 5.7 teraflops. Reportedly, the service is priced at a mere 50 cents per hour per CPU, which sounds cheap until you consider that each Blue Gene system is made up of as many as 64 racks, each with 1,024 dual CPU nodes per rack. Additionally, efficient use of the highly parallel, interconnected machine requires applications that are specifically tailored for its architecture, so you probably should hang onto the old PC for word processing and accounting functions.

Cross-Platform Compilable Basic

If you have an interest in developing software that runs natively in Windows, Mac OS, and Linux all from the same source code, and if Basic is your programming bag, you may need to take a look at REALbasic 2005 from REAL Software, Inc. According to the vendor, REALbasic 2005 is highly compatible with Visual Basic, and Visual Basic developers can be instantly productive with it.

In addition, the product includes a conversion utility to help migrate existing Visual Basic projects to REALbasic where they can be compiled for Windows, Macintosh, and even Linux. It also creates self-contained executables that do not require dynamic link libraries (DLLs), external frameworks, or virtual machines.

This is aimed at minimizing installation and deployment problems commonly associated with some cross-platform development tools. REALbasic professional edition lists for $499.95 but is temporarily offered at an introductory price of $399.95. The standard edition starts at $99.95. For more information, visit **www.realsoftware.com/demo15**

One-Inch Drive Stores Six Gigs

The Hitachi 3K6 microdrive stores six gigabytes. Photo copyright 2005 Hitachi Global Storage Technologies. All Rights Reserved.

Late in February, Hitachi began shipping the model 3K6 hard drive, aimed at miniature MP3 players and other miniature devices. It stores six gigabytes in a one-inch format, which translates into as many as 3,000 songs, 6,000 photos, or eight hours of MPEG-4 video (depending on the compression rate). The drive is available in both removable Compact Flash Type II and embedded versions, and the retail price is $299.00. Pertinent specs include 3,600 rpm platter speed, 78 billion bits/square inch density, 8.3 microseconds average latency, and a 12 microsection

average seek time. A follow-up four-gigabyte version is in the works that will sell for $199.00. Finally, later this year, Hitachi plans to release a higher-capacity version (presently referred to as "Mikey," the baby microdrive) with eight to 10 gigabytes of storage space.

FBI Virus

A recent alert from the Federal Bureau of Investigation (FBI) warns of an ongoing mass email scheme in which unsolicited messages inform recipients that their Internet use has been monitored by the agency's Internet Fraud Complaint Center and that they have accessed illegal websites. The message then directs the recipient to open an attachment, which turns out to be a virus. If you receive such a message, you are advised to (a) refrain from opening the attachment, and (b) report it to the Internet Crime Complaint Center at **www.ic3.gov**

Mozilla Update Available

As of this writing, there are some 27 million users of the Firefox 1.0 browser, and all of them are vulnerable to several security flaws. The most serious of them could allow a hacker to gain full control over your PC. Available at **www.mozilla.org** you now can download Firefox 1.01, which fixes 17 of these problems and includes fixes to protect you from Web address spoofing and other vulnerabilities. More information about the new release is available in the notes at **www.mozilla.org/products/firefox/releases**

Circuits and Devices

Tap into Earth Music

The aurora borealis emits strong radio waves that can be converted to audio signals when channeled through a VLF receiver. Photo courtesy of NASA.

Maybe you're tired of the usual stuff that comes out of your radio — overproduced and uninspired contemporary dance ditties, recycled Top-40 oldies, pompous talk show hosts, et al. Well, how about if you could listen to the largely impromptu radio emissions of the Earth itself?

In fact, thousands of very low frequency (VLF) receivers are already tuned in to "Earth music" thanks to the Interactive NASA Space Physics Ionosphere Radio Experiments (INSPIRE) program. Listening in the range of 0 to 20 kHz, you can hear various natural and man-made phenomena, including sferics (lightning impulse signals), tweeks (sferics that are ducted into the ionosphere), whistlers (signals that return to Earth via a magnetic field line), choruses (many simultaneous whistler-like emissions), and others. (You'll also hear a lot of 60-cycle hums if you're within 500 meters of any kind of AC power source, so forget about locating the receiver in your living room.) The sounds change with geographic location, time of day, weather, seasons, and so on, so your reception will contain more variety than the average Oprah show. If you are curious about the concept, visit **http://image.gsfc.nasa.gov/poetry/inspire**

You can listen to audio samples, view spectral representations of them and, if you want to take the plunge, buy a VLF receiver kit for $80.00, plus shipping. Not a bad price for getting the whole planet to sing to you.

Digital Tutorial Introduced

If you made it through the course in basic electronics but didn't quite grasp the finer points of digital design, Luna Labs has a deal for you. For

$179.00, they will send you the SnapLogic Tutorial and Digital Lab Set, which includes a 175-page manual and a 25-piece hardware kit. You can experiment with logic circuits without any need for breadboards, wires, test equipment, and other paraphernalia. Instead, you can use the reusable SnapLogic cards that come with the kit.

Covered subjects include basic theory, boolean expressions, logic switches, basic and derived gates, buffers, sequential logic, and more. Twenty-plus hands-on exercises are included. And, by George, they even throw in two AAA batteries. Details are available at **www.lunalabs.com**

Industry and the Profession

Macintosh Creator Dies at 61

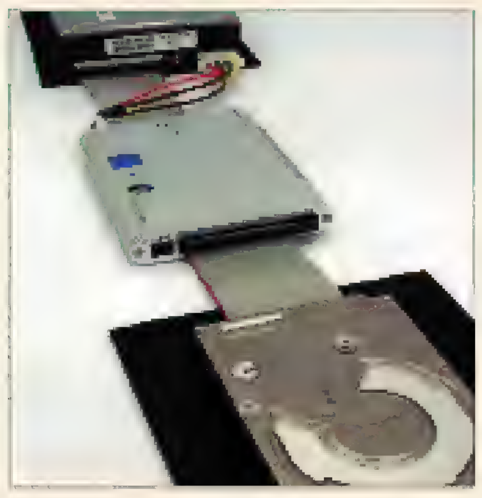
Jef Raskin, Mac creator, wearing the Microoptical head-mounted display. Photo courtesy of Aza Raskin.

Jef Raskin, a mathematician, orchestral soloist and composer, professor, bicycle racer, model airplane designer, and pioneer in the field of human-computer interactions, died peacefully at home in California on February 26, 2005, surrounded by his family and loved ones. He had recently been diagnosed with pancreatic cancer.

Jef created the Macintosh computer as employee Number 31 at Apple in the early 1980s, revolutionizing computer interface design. He invented "click and drag" and many other methods now taken for granted by computer users. He named the Macintosh project after his favorite variety of apple, the McIntosh, modifying the spelling for copyright purposes. Raskin strongly believed that computers should make tasks easier for people, not the other way around.

For 25 more years, his work focused on improving interfaces, culminating in his book, *The Humane Interface* (Addison-Wesley, 2000). Jef created the Raskin Center for Humane Interfaces (RCHI, **www.raskincenter.org**), which is set to release a preview of Archy, a collection of his design principles. Archy is said to redesign the basic building blocks of computing to demonstrate a new paradigm for computer use. RCHI will continue under the technical leadership of Jef's son, Aza Raskin. **NV**

"HONEY, WE'VE SHRUNK THE DISK JOCKEY!"



Diskology, Inc., announces that they've shrunk the Disk Jockey, their award-winning hard disk duplicator / backup / diagnostic tool. The 7-in-1 tech tool can now easily fit into the palm of one's hand.

The Disk Jockey has been called "a dream come true for any PC hobbyist or technician" — *Computer Power User*, Oct. 04 and has been deemed "a worthy addition to the IT professional's toolbox" — *Macworld*, December 04. The product also recently won the Editor's Choice award from *MacAddict Magazine* (April 05) where it was called "geekily cool and useful."

The Disk Jockey is a "Swiss Army Knife" of a product. The Disk Jockey can be used on either a Microsoft Windows or Apple Macintosh computer or as a stand-alone device. The Disk Jockey mounts IDE hard drives via USB 2.0 or Firewire (IEEE 1394), as well as mirrors, spans, copies, compares, tests, and erases hard disk drives using either a one-pass or three-pass erase per National Security Administration (NSA) guidelines. Testimonials on how the Disk Jockey is being used by IT and MIS departments, as well as a variety of other computer professionals, hobbyists, and forensic experts can be found on Diskology's website.

Diskology offers SATA adapters, as well as longer cables for the Disk Jockey. The Disk Jockey retails for $329.00. More information on the Disk Jockey or on Diskology, Inc., can be found at their website. Testimonials and reviews can be found at **www.diskology.com/djtestimonials.html**

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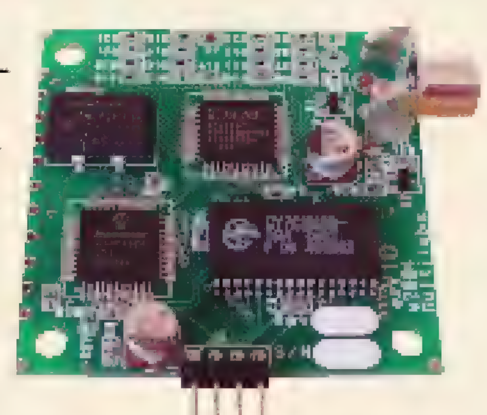
NEW AND IMPROVED *ezVID* SERIAL VIDEO MODULE



Multilabs has released a new version of its popular ezVID Serial Video Module. The ezVID 2.0 has all the same features of the original ezVID plus all new features that make it more powerful and faster than the original. Along with the original command set which included place built-in character, place user character, add user character, clear screen, change background color, and reset, new commands were added to allow you to draw lines, clear areas of the screen, place characters in opaque mode, set individual pixels, place double-sized characters, and use a floating character.

In addition to these new commands, one of the original commands was improved as well, by making the clear screen command 38% faster.

The ezVID 2.0 comes with the same built-in character set that takes care of all the basic needs and has a generous amount of space to define 256 of your own custom characters. The ezVID 2.0 comes in the same simple-to-use SIP module that measures 2" x 2" and uses the same communications protocol, asynchronous 9600 baud TTL level serial.

It is 100% compatible with the original command set, size, power, and communications protocol, so an ezVID 2.0 can be inserted into devices already using the original ezVID without any alteration.

The ezVID 2.0 sells for $64.95 and is available through the Multilabs website. (It is only available in NTSC.)

MULTILABS
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Email: **support@multilabs.net**
Web: **www.multilabs.net**
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SITEPLAYER TELNET™ SERIAL TO ETHERNET MODULE

NetMedia, Inc., announces their next generation of embedded device servers. SitePlayer Telnet™ interfaces serial devices to a TCP/IP stack at a very competitive single quantity price of $29.95. The SitePlayer Telnet module gives OEMs and product designers the ability to quickly and cost-effectively bring their products to market. Now, you can enable your legacy serial devices to communicate across Ethernet with a simple, socketed module the size of a postage stamp.

NetMedia's Telnet device transfers binary data using TCP/IP or UDP protocol through a fully configurable serial port at speeds of up to 115,200 baud. Using a web browser, you can configure, password protect, and upload software updates to SitePlayer Telnet. TCP/IP and UDP port security is provided via source IP and mask protection.

Configurable settings are stored in non-volatile memory. Two SitePlayer Telnet systems can easily be configured as client and server to create a "virtual serial cable," allowing you to span serial ports across great distances. Siteplayer Telnet is also available in a packaged system for $79.95.

NET MEDIA, INC.
10940 N. Stallard Pl.
Tucson, AZ 85737
520-544-4567 Fax: **520-544-0800**
Email: **support@netmedia.com**
Web: **www.siteplayer.com**
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EASY-USE SOFTWARE FOR DESIGNING YOUR OWN FRONT PANELS

FrontDesigner is a new software package that allows engineers to design professional-looking front panels for home-made or small production run devices. FrontDesigner has a host of drawing functions for rectangles, polygons, ellipses, labels, drillings, etc., and all objects can be grouped into complex symbols.

Specialized functions cope with rotation, stretching, mirroring, drilling, milling, etc. Rounded and interpolated contours are possible, as well as chamfers. Now your product can have precisely-fitted symbols, scales for pots, warning signs, etc. (color or b/w). You can even print out a mirror-image on transparent film so when it is mounted, the symbols won't wear off. The HPGL export function creates PLT files, so you can mill and engrave your front panel, or export the image as a BMP, JPG, or EMF file with resolution up to 600 dpi.

Symbol-library: FrontDesigner is equipped with a symbol-library, which includes many symbols of different themes like audio, home, climate, vehicle, and so on. Of course, you can add your own symbols to extend the library. Even bitmaps or metafiles with symbols from the Internet or company logos can be added to the library.

Scale-assistant: The integrated scale-assistant helps you to create perfect scales of every kind. Linear or logarithmic, round or flat, dashed or dotted — the scale-assistant will always create a perfect scale from your parameters. Any changes of the parameters will be displayed immediately, so you always have visual control. Just one click and the scale will be on your front panel. You can even save and load the scale-assistant's parameters.

Pens, brushes, and colors: With FrontDesigner, pens and brushes are available in all colors with different styles. Define and store your own pens and brushes with memorable names like pencil, felt pen, ballpoint, brush, etc. Broken lines and hatches are possible, as well.

Measure: FrontDesigner creates measuring objects that are great as a construction aid and for manufacturing instructions. Simply click to two points of the front panel and the distance is calculated automatically. Another click completes the measure object with arrows, lines, and figures.

Milling, engraving, HPGL-Export: With FrontDesigner, your front panels can be milled or engraved. The HPGL export creates plot files, which can be used to produce precise front panels with CNC machines. FrontDesigner can

handle AutoCAD SHX "single-stroke" fonts, guaranteeing a perfectly readable result. Another special feature of FrontDesigner is the panel-cut function. This function creates rectangular or round cuts on your front panel. By choosing the milling width, the cuts will be calculated exactly.

Printing: FrontDesigner offers print-preview, mirrored printouts, construction plans which show drilling, millings, or measurements only. FrontDesigner can print out over several pages, automatically divided. FrontDesigner is available for $79.95 (qty 1) from Saelig Co., Inc.

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ALL NEW STEREO LOUDSPEAKER SYSTEM

TDL® Technology, Inc., announces their Model TSMD-1 Stereo Loudspeaker System. The combination of the aluminum cone woofers with a planar (ribbon) tweeter give the TSMD-1 a very fast response. They are especially well suited for reproducing musical instruments with a fast attack time such as the piano, acoustic guitar, harp, and harpsichord, but extensive listening tests show they are equally good with vocals, chamber music, the pipe organ, and a full orchestra.

Because of their fast response, they are somewhat bright but they have outstanding clarity. Potential customers are invited to come and listen and to bring their own recorded music (although we have an extensive library from which to choose).

Price is $995.00 USD per pair plus shipping. Availability is about six weeks as each pair is custom built for the buyer. A three-page data sheet in PDF format can be downloaded from TDL's website.

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Electronic Theories and Applications From A to Z

Let's Get Technical

The Root of the Problem: Performing Integer Square Roots

When I first began playing with microprocessors, the initial eight-bit CPUs had limited eight- and 16-bit addition and subtraction capabilities, but could not multiply or divide. I always had to write an eight-bit multiply subroutine when I needed one.

When 16-bit microprocessors came around, the instruction sets were much more powerful. Sixteen- and 32-bit multiplication and division capabilities were now available, and while this was an improvement, it was still impossible to do anything beyond the basic four math operations unless you wrote a ton of code or added a co-processor. Even something as simple as the square root operation was not available.

So, let's make one. Let's design a subroutine that will calculate the integer square root of another integer. Examine Table 1 for some integer square root examples.

In applications where the integer root of a value is good enough (estimating distance in a video game, for instance), we are able to take advantage of a simple formula to perform the following calculation:

$$Est = \frac{\frac{N}{Est} + Est}{2}$$

In this formula, N is the input number and Est is the estimated square root. This formula is an iterative formula. We begin with an initial guess for the first value of Est. One trip through the formula adjusts Est to a new value that is closer to the square root than the initial guess. After several trips through the formula, the value of Est will settle to the integer square root of the input number N. This process is illustrated in Table 2.

Depending on the initial estimate, the number of iterations through the formula will vary before the estimate becomes stable. In Table 2, all of the estimates fall well within the 10-pass limit chosen for the table. In actual operation, 10 passes may not be enough. We will investigate this feature when we have working code.

Note that the formula works just as well for floating-point numbers.

N	Square Root of N	Integer Square Root of N
9	3	3
10	3.162	3
25	5	5
150	12.247	12

Table 1. Integer square root examples.

Iteration	Initial Est = 4	Initial Est = 100	Initial Est = 500
1	14	50	250
2	10	26	125
3	10	14	87
4	10	10	44
5	10	10	23
6	10	10	13
7	10	10	10
8	10	10	10
9	10	10	10
10	10	10	10

Table 2. Finding the integer square root of 100.

How do we turn the equation into working code? One way is to write pseudo-code, a generic description of the steps the program needs to perform that do not contain any specific programming statements. The pseudo-code for the square-root formula looks like this:

```
Subroutine SQROOT
      Initialize Estimate
      Initialize loop counter to 10
      Repeat
            Divide N by Estimate
            Add Estimate to result
            Estimate = result / 2
            Decrement loop counter
      Until counter equals 0
      Return
End SQROOT
```

Now, the trick is to convert each statement into one or more assembly-language or high-level-language statements. In C, we could use something like this:

```
void sqroot()
{
        estimate = 65535;
        for(pass = 0; pass < 10; pass++)
        {
                temp = n / estimate;
                temp = temp + estimate;
                estimate = temp / 2;
        }
}
```

Pseudo-code	Intel 80x86 Assembly Language
Subroutine SQROOT	SQROOT PROC NEAR
Initialize Estimate	MOV BX,0FFFFH
Initialize loop counter to 10	MOV CX,10
Repeat	ITER:
	PUSH AX
	PUSH DX
Divide N by Estimate	DIV BX
Add Estimate to result	SUB DX,DX
	ADD AX,BX
	ADC DX,0
Estimate = result / 2	MOV BX,2
	DIV BX
	MOV BX,AX
	POP DX
	POP AX
Decrement loop counter	
Until counter equals 0	LOOP ITER
Return	RET
End SQROOT	SQROOT ENDP

Table 3. Converting from pseudo-code to assembly language.

There are lots of similarities between the pseudo-code and the C statements, but the more interesting challenge is how to code the solution in assembly language. For selfish reasons, let us use Intel 80 x 86 instructions. Table 3 shows the pseudo-code and the associated 80 x 86 assembly language. Some things to bear in mind while looking at the code:

- Register BX is used to store the 16-bit estimate. Its initial value is 65,535 (0FFFFH).

- Registers DX and AX contain the 32-bit input number N. DX holds the upper 16-bits of the number.

- The DIV instruction divides the 32-bit DX:AX value by a supplied 16-bit value (BX in this example). AX contains the 16-bit quotient, while DX holds the 16-bit remainder.

- The stack is used to save a copy of the input number N (held in registers DX and AX), since they are destroyed when computing the new estimate.

- The CX register is automatically decremented and tested by the LOOP instruction.

Sometimes a single pseudo-code statement requires more than one assembly language instruction (such as when the result is divided by two). Occasionally, one assembly language instruction covers more than one pseudo-code statement (the LOOP instruction does this, for example).

You may have noticed that there is no reference to the PUSH and POP instructions in the pseudo-code (no statements like "save N" or "recall N" anywhere). These instructions are needed to compensate for the operation of the DIV instruction. In a different assembly language (for a different CPU), they may not be needed at all.

Once the code has been developed, we need to test it. Is it enough to try just one value and conclude the code works for all input values? In most cases, no. We must pass many different numbers into the subroutine and make sure all the results are correct. But how many is many? Four? Ten? One thousand input numbers? With a 32-bit integer range, we could enter a number as large as 4,294,967,295 or as small as zero, with over four billion others in between. Do we have the time to wait until all four billion inputs have been checked? Probably not. So, we try

Iteration	Initial Est = 65,535
1	32,767
2	16,383
3	8,191
4	4,095
5	2,047
6	1,023
7	511
8	255
9	127
10	63
11	31
12	15
13	7
14	3
15	1
16	0

Table 4. When the input number is N=0, it takes 16 passes to get the correct result.

a few values and see what happens. If the routine gives the correct result for each input, that will be a good start toward having faith in its overall correctness.

Let us begin by computing the integer square root of N = 100,000,000. In hexadecimal, this is 5F5E100H. To use the code in Table 3, we must load this number into registers DX and AX in the following way:

```
MOV  AX,0E100H          ;lower 16-bits of N
MOV  DX,5F5H            ;upper 16-bits of N
```

Once AX and DX have been loaded, we call the SQROOT procedure. When SQROOT returns, the final result (the final estimate) is saved in register BX.

A source file containing the SQROOT procedure is as follows:

```
;Program SQROOT.ASM: Calculate integer square-root.
;
        .MODEL SMALL

        .CODE
        .STARTUP

        MOV     AX,0E100H         ;lower 16-bits of N
        MOV     DX,5F5H           ;upper 16-bits of N
        CALL    SQROOT

        .EXIT

SQROOT PROC NEAR
        MOV     BX,0FFFFH
        MOV     CX,10
ITER:   PUSH    AX
        PUSH    DX
        DIV     BX
        SUB     DX,DX
        ADD     AX,BX
        ADC     DX,0
        MOV     BX,2
        DIV     BX
        MOV     BX,AX
        POP     DX
        POP     AX
        LOOP    ITER
        RET
SQROOT ENDP

        END
```

When the EXE file created from this source is executed, nothing is displayed in the command window and you just get the DOS prompt back. That is because there is no code to display the results. However, since we are just testing the code, we can use the DEBUG utility to load the executable and then trace the instructions to see how the code works.

Here is a partial register trace of the code using the DEBUG utility:

```
AX=0000  BX=FFC0  CX=0041  DX=0B5D  SP=FFC0  BP=0000
SI=0000  DI=0000
DS=0B5D  ES=0B49  SS=0B5D  CS=0B59  IP=0017   NV UP EI
NG NZ NA PE NC
0B59:0017 B800E1         MOV     AX,E100
-t

AX=E100  BX=FFC0  CX=0041  DX=0B5D  SP=FFC0  BP=0000
SI=0000  DI=0000
```

```
DS=0B5D  ES=0B49  SS=0B5D  CS=0B59  IP=001A   NV UP EI
NG NZ NA PE NC
0B59:001A BAF505        MOV      DX,05F5
-t

AX=E100  BX=FFC0  CX=0041  DX=05F5  SP=FFC0  BP=0000
SI=0000  DI=0000
DS=0B5D  ES=0B49  SS=0B5D  CS=0B59  IP=001D   NV UP EI
NG NZ NA PE NC
0B59:001D E80400        CALL     0024
-p

AX=E100  BX=2710  CX=0000  DX=05F5  SP=FFC0  BP=0000
SI=0000  DI=0000
DS=0B5D  ES=0B49  SS=0B5D  CS=0B59  IP=0020   NV UP EI
PL ZR NA PE NC
0B59:0020 B44C          MOV      AH,4C
-
```

First notice that AX changes from 0000 to E100 after the first MOV. Then notice that register DX changes from 0B5D to 05F5 after the second MOV. The CALL 0024 instruction is the call to the SQROOT procedure located at offset 0024 in the current code segment. By using the p command instead of the t command, DEBUG treats all of the instructions in SQROOT as if they were part of the CALL instruction and executes the entire procedure, returning with the value of BX that contains the integer square root result. This value, 2710H, converts to 10,000 decimal, the correct square root of 100,000,000. So, the SQROOT routine works for this input value. Make up your own input number, convert it to hex, change the source code, reassemble, and retest.

Once we are convinced the code gives the correct answers, there are two areas to investigate:

1. Is the choice of the initial estimate and/or the number of loop iterations correct?

2. Is there a limit on the input number size?

To answer these questions, look at Table 3 to see that the initial value placed into BX (the initial estimate) is 0FFFFH (65,535 decimal). Why this number? Why not 1, or 10, or 1,500, or 25,000? The value 1 would be a fine initial value on paper, but poses a problem in the DIV instruction. If the 32-bit input number N stored in DX and AX is divided by 1, the result is another 32-bit number, not a 16-bit quotient and 16-bit remainder. The DIV instruction sets an overflow flag in this case.

Since the code in Table 3 ignores overflows after each DIV instruction, that could lead to incorrect results, unless the size of the input number is limited to prevent overflows. The largest quotient we can get is 0FFFFH (65,535 decimal), which implies the largest input number is 65,535-squared or 4,294,836,225 (0FFFE0001H). This is not the largest input number that can be passed into SQROOT, but values larger than this (plus the maximum remainder of 65,534) will cause an overflow. It is also okay to begin with an initial estimate that is larger than the correct result, as the estimate will move closer to the correct answer with each pass through the equation.

Now, do we have enough iterations? Take a look at the example in Table 4 for proof that 10 passes through the equation is not enough for our 32-bit input range.

Since the result can only get smaller by a factor of two for each pass through the equation, we need 16 passes to divide the initial large estimate down to zero in this worst-case scenario (N = 0).

So, we must make a slight change to the code to fix the iteration problem, and then we keep testing forever or for as long as the code is used. Someday, someone may input a 32-bit number that causes the code to calculate the wrong results. Hopefully, they will send us a note so we can issue an update. **NV**

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- ✔ Sine, Square, or Triangle waveform

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To begin with we increased the frequency range all the way up to 5MHz and all the way down to 0Hz (yes, we mean zero...or DC!) continuously in 0.1Hz steps across the entire range! Then we gave it a variable output level all the way up to 10V peak to peak in either Sine, Square, or Triangle waveforms! You can also provide a DC offset to the output to recreate TTL, 4000 series logic levels, low voltage logic levels, AC waveforms with a DC component, or just plain AC signals!

SMT and DDS technology is used throughout the SG560 for ultimate performance and reliability. If you're looking for a lab quality sig gen at a super hobbyist price, the brand new SG560 fits the bill...and a whole lot more!

SG560WT	**Audio/RF Signal Generator, Factory Assembled**	**$329.95**

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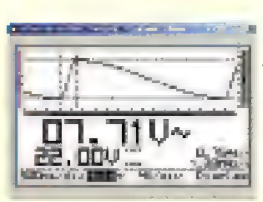
- ✔ Backlit LCD display
- ✔ RS232 output (40MHz model only)
- ✔ Charger, case, probes included

We've seen a lot of portable scopes and scope/meters, and we've also seen the price tags! They have always been way out of the reach and budget of the hobbyist. No more! Now for close to the price of a good DMM you can have a personal scope that also has DVM readout for dBm, dBV, DC, and True RMS! Frequency readout is also displayed on the screen through markers, plus the scopes have two memories for digital storage.



The 40MHz model also includes an RS232 output and serial interface to capture the screen display on your scope to your PC at the mere push of a button! These scopes run on 5 standard AA Alkaline batteries (not included) which provide up to 20 hours of use. You can also use rechargable AA NiMH batteries instead and they'll be charged with the included power supply! Both units come with a custom foam lined high impact carrying case, set of high quality scope probes, AC power adapter and a comprehensive user's manual. If you're working with electronic circuits, automotive applications, audio and stereo applications or other applications, the personal scope is for you...at a price that can't be beat!

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- ✔ Backlit LCD display with data hold
- ✔ Manual and auto ranging
- ✔ Includes probes, RS232 cable, & software

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Features both auto and manual ranging with a large 3¾ digit display with a 38 segment analog bargraph. Selectable backlight and data display hold features are also included. Plug in the provided DB9 serial cable to your PC, load the included software, and you're off and running with a remote control digital multimeter from your PC! Includes standard test probes, temperature test probes, professional rubber holster, RS232 cable, installed 9V battery, Windows software CD, all in a neat travel case.

DVM345DI Dual Display DMM With RS232 Output	**$84.95**

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Uses exotic, low barrier microwave detector diodes to give exceptional sensitivity which can see signals down to microwatt levels! A great low cost way of checking for RF. Fully assembled and tested, and includes standard banana plugs for use with any standard VOM, DMM or voltmeter. If you need to measure RF and don't want to spend big bucks, here you go!

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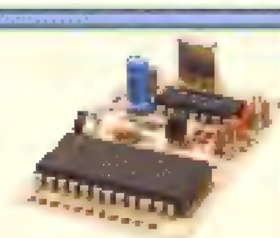

Strappable to detect any single DTMF digit. Provides a closure to ground up to 20mA. Connect to any speaker, detector or even a phone line. Runs on 5 VDC.

TT7	**DTMF Decoder Kit**	**$24.95**

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Produces the upward and downward wail of a police siren. Produces 5W output, and will drive any speaker! Runs on 6-12 VDC.

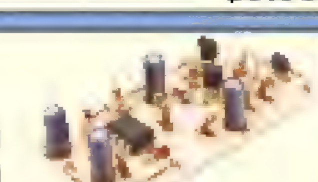
SM3	**Electronic Siren Kit**	**$7.95**

Universal Timer

Build anything from a time delay to an audio oscillator using the versatile 555 timer chip! Comes with lots of application ideas. Runs on 5-15 VDC.

UT5	**Universal Timer Kit**	**$9.95**

Voice Switch



Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch, or to turn on a recorder or light! Runs on 6-12 VDC and drives a 100 mA load.

VS1	**Voice Switch Kit**	**$9.95**

Tone Encoder/Decoder

Encodes OR decodes any tone 40 Hz to 5KHz! Add a small cap and it will go as low as 10 Hz! Tunable with a precision 20 turn pot. Runs on 5-12 VDC and will drive any load up to 100 mA.

TD1	**Encoder/Decoder Kit**	**$9.95**

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SA7	**RF Preamp Kit**	**$19.95**

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Touch on, touch off, or momentary touch hold, your choice! Uses CMOS technology. Runs on 6-12 VDC and drives any load up to 100 mA.

TS1	**Touch Switch Kit**	**$9.95**

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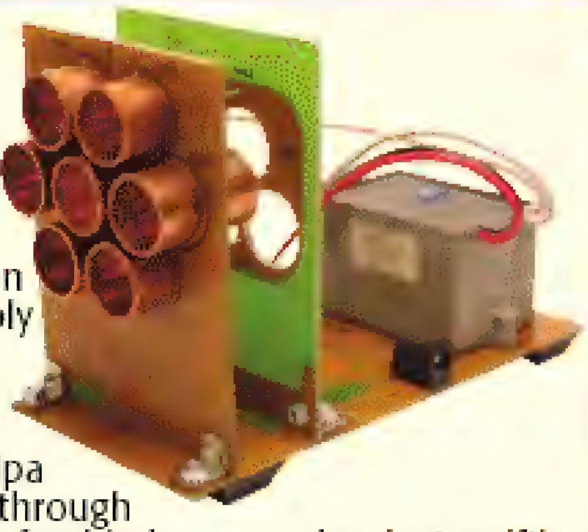

- ✔ Generates negative ions!
- ✔ Blast of fresh air, no noise!
- ✔ Generates DC, not pulsed!
- ✔ 7.5kV DC negative, 400uA!

This nifty kit includes a pre-made high voltage ion generator potted for your protection, and probably the best one available for the price. It also includes a neat experiment called an "ion wind generator". This generator works great for pollution removal in small areas (Imagine after Grandpa gets done in the bathroom!), and moves the air through the filter simply by the force of ion repulsion! No fan blades, no noise, just swiftly moving, charged air.

Learn how modern spacecraft use ions to accelerate through space. Generate negative ions for health and healing! Includes ion power supply, 7 ion wind tubes, and mounting hardware for the ion wind generator.

IG7	**Ion Generator Kit**	**$64.95**
AC125	**110VAC Power Supply**	**$9.95**

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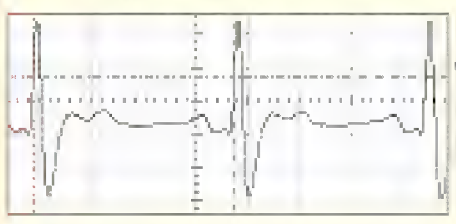

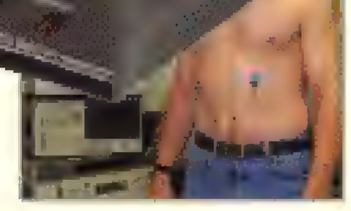

Enjoy learning about the inner workings of the heart while at the same time covering the stage-by-stage electronic circuit theory used in the kit to monitor it.

The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors. The fully adjustable gain control on the front panel allows the user to custom tune the differential signal picked up by the probes giving you a perfect reading every time! Multiple "beat" indicators include a bright front panel LED that flashes with each heart beat, an adjustable audio output to hear the beat, and of course, the monitor output to view on a scope, just like in the ER! Operates on a standard (and safe) 9VDC battery. Includes matching case for a great finished look. The ECG1 has become one of our most popular kits with hundreds and hundreds of customers wanting to get "Heart Smart"!

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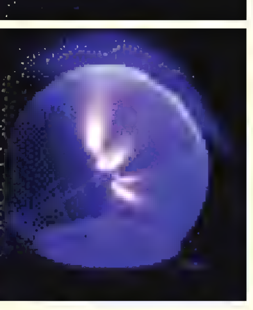
- ✔ Build your own plasma balls!
- ✔ Generate up to 25kV @ 20KHz from a solid state circuit!



This new kit was conceived by one of our engineers who likes to play with things that can generate large, loud sparks, and other frightening devices. The result... the PG13 Plasma Generator designed to provide a startling display of high voltage!

It produces stunning lighting displays, drawing big sparks, to perform lots of high voltage experiments. In the picture, we took a regular clear "Decora" style light bulb and connected it to the PG13 - WOW! A storm of sparks, light tracers and plasma filled the bulb. Holding your hand on the bulb doesn't hurt a bit and you can control the discharge! It can also be used for powering other experiments; let your imagination be your guide! Can also be run from 5-24VDC so the output voltage can be directly adjusted.

PG13	**Plasma Generator Kit**	**$64.95**
PS21	**110VAC input, 16VAC output power supply**	**$19.95**

Robot Car

- ✔ Senses sound and turns!

This little car may not look like a robot, but it sure acts like one! Designed to look like a futuristic vehicle, the on-board "power train" drives it in a straight path. But a highly sensitive microphone on the board detects sounds, and changes the direction of the car! You can whistle to it, yell at it, and it will change directions! When it runs into a wall or obstacle, it moves away from it! Runs on 2 standard AA batteries (not included).

KSR1	**Robot Car Kit**	**$19.95**

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- ✔ See in the dark!

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IR1	**IR Illuminator Kit**	**$29.95**

Electronic Watch Dog NEW!

- ✔ Sound activated barking dog on a PC board!

It's nice to have a barking dog to react to someone at our door. But not all of us can have a dog! No problem there, build your own! Two distinct barking sounds are sound activated with a built-in microphone that has adjustable sensitivity. I wish my dog had adjustable sensitivity! This dog eats 9-12VDC. Easy kit assembly.

K2655	**Watch Dog Kit**	**$32.95**

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- ✔ Amplifies sound 50 times!

The "Super Ear" is an ultra high gain amplifier that includes two super sensitive mics at a 45 degree angle to give you a true stereo output. Includes on/off switch and volume control. Standard audio jack is provided for audio output. Runs on 3 standard AAA batteries (not included). Easy to assemble and fun to use!

MK136	**Super Ear Kit**	**$9.95**

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Micro Memories

The IBM PC and Its Continuing Repercussions

In the 1999 made-for-cable movie, "Pirates of Silicon Valley," the filmmakers chose to illustrate how significant a 1980 meeting between Bill Gates and IBM was by having John Di Maggio, the actor playing Steve Ballmer (Gates' longtime lieutenant), walk out of the scene, up to the camera, and tell the viewers that this — *this!* — was the most important moment in computer history.

It was the moment when Bill Gates talked IBM into letting him keep control over his operating system and license it to others. "Besides, the money's in the hardware," one white-shirted IBM employee responds in blissful cluelessness to Gates' request. The repercussions would almost immediately begin to echo from it.

Of course, Di Maggio (or, more precisely, the screenwriter) was right: this really was a key moment. It launched Gates and Paul Allen on the way to becoming *gazillionnaires* and it would eventually knock Apple off their throne as kings of the computer world.

The building of the IBM PC had profound implications far beyond IBM, of course. It created a marketplace for computer clones, as anybody could build a PC with the same chip and operating system as IBM's and run the exact same software on it.

In contrast, Apple's closed system, while certainly having numerous benefits, caused Apple's price to remain higher, its available software lower, and ultimately cemented Apple's position in the PC wars as first out of the gate but eventually listed as an also-ran.

IBM's Model 5100: The Abortive Predecessor

But then, IBM itself was originally

an also-ran when it came to the PC itself. In the 1970s, they pooh-poohed the idea of small, personal computers and continued to push their vaunted mainframes. This created the environment that allowed Xerox to develop their breakthrough microcomputers with graphic interfaces at their Palo Alto, CA, Research Center. But they too failed to see that there wouldn't be much of a market for them.

In 1975, IBM tried to produce a small, portable computer of their own, the IBM 5100. It used a tape drive for programming storage and shipped with 16 to 64K of RAM. Its configuration could be adjusted for various applications.

That's the good news. The bad news was that variable configuration had a variable suggested price of between $9,000.00 and $20,000.00.

Because of this, the late 1970s ended up being dominated by Apple, Tandy (with their TRS-80, sold in RadioShack stores), and Commodore, with their PET line of personal computers, all of whose principal models were available for around $1,500.00 or less.

Getting off the Sidelines

Standing on the sidelines at the start of the 1980s and watching the sales of affordable PCs going through the roof, execs at IBM wondered how to get into the game.

They wanted to do so rather quickly, so they relied on outside components to a surprising degree. IBM chose Intel's 8088 chip to power the unit, which helped establish Intel's reputation as *the* chip manufacturer, a reputation it enjoys to this day.

Of course, it was Microsoft who really benefitted from being associated with the IBM PC. IBM approached Bill Gates initially because they wanted a version of the Basic operating system embedded on a chip in their planned machine. Gates' firm had plenty of experience supplying the language to existing computer manufacturers.

But while Basic is an easy-to-learn language, it's not very powerful. IBM wanted a more sophisticated operating system. Gates tap-danced around the issue and then, shortly after, bought all of the rights to an operating system called QDOS (short for Quick and Dirty Operating System) from a then struggling Northwest computer startup called Seattle Computer Products. They, in turn, had borrowed heavily from the CP/M operating system.

Microsoft managed to secure a licensing deal with IBM that ensured the nascent start-up with huge revenues in years to come and helped build their now sprawling corporate campus in Redmond, WA.


Stanley Kubrick at one of the early PCs. Photo courtesy of Alan Bowker.

Meet the 5150

IBM dubbed the completed unit the model number 5150 and introduced it to the world during a Manhattan, NY, press conference on August 12, 1981. The base model initially retailed for $1,565.00 and included a 4.77-MHz Intel 8088 processor, 64K of RAM, and a single-sided 160K, 5.25-inch floppy drive.

In a curious bit of synchronicity, the rock group Van Halen would make the number 5150 even more famous a few years later by using it as an album title. Were they sponsored by IBM? Nope, it was purely coincidental, as the number is also Los Angeles, CA, police shorthand for "escaped lunatic."

The de Facto Business PC

Most felt that IBM's PC was inferior to Apple's products, but because of IBM's prior button-down reputation in the corporate mainframe market and their enormous advertising budget, the unit quickly became the de facto business computer. Apple — thanks to its superior graphics capabilities — ended up pursuing more "artsy" markets: designers, printers, CADCAM, etc. While the graphics capabilities of IBM-style machines have improved exponentially, to a certain extent, the delineation continues to this day (just as Intel and Microsoft's reputations are largely built on a machine designed 25 years ago).

IBM's early use of an open-system architecture had other repercussions as well: It made the unit's hardware easy to copy, and by the end of the 1980s, numerous manufacturers were building "clones" that could run any software that IBM's PCs could run. More importantly, they sold for considerably less. Compaq and Dell entered the picture in the mid-1980s, and even pre-PC manufacturer Commodore held on to life for a few more years by producing IBM clones. (Mine wasn't too bad a machine. I bought it in 1989 and used it for simple small business applications for the next five years or so.)

IBM still sells PCs under their label, of course, but they no longer dominate the marketplace. The repercussions of their entering it still echo to this day, as many people refer to their machines as either an IBM-compatible or an Apple.

Microsoft and Intel owe much thanks to that fateful decision of IBM to outsource components to speed up release of their Apple killer. It wasn't entirely, but the IBM PC was the proverbial "killer app" that eventually put a PC on everyone's desks. **NV**

The IBM 704 mainframe was the image IBM was trying to overcome with their PCs.

News Bytes

Car That Runs On Compressed Air

A Korean company has created a car engine that runs on air. The engine, which powers a pneumatic-hybrid electric vehicle (PHEV), works alongside an electric motor to create the power source. The system eliminates the need for fuel, making the PHEV pollution-free.

Cheol-Seung Cho, of Energine Corporation, told CNN the system is controlled by a computer inside the car, which instructs the compressed-air engine and electric motor what to do.

The compressed air drives the pistons, which turn the vehicle's wheels.

The air is compressed using a small motor, powered by a 48-volt battery, which powers both the air compressor and the electric motor.

Once compressed, the air is stored in a tank, Cho said.

"The compressed air is used when the car needs a lot of energy, such as for starting up the car and acceleration. The electric motor comes to life once the car has gained normal cruising speed."

He said the system was relatively simple to manufacture and could be easily adapted to any conventional engine system.

"You could say our car has two hearts pumping. That is, we have separate motors running at different times, both at the time when they can perform most efficiently."

Cho also said the system could reduce the cost of vehicle production by about 20 percent, because there was no need to build a cooling system, fuel tank, spark plugs, or silencers.

Cho hoped to see PHEVs on streets in the near future.

Peter Kemp, editor of *Petroleum Intelligence Weekly*, told CNN that one of the biggest challenges for the invention was persuading the general public to embrace it.

"For this invention to take off, you'd need to get the backing of a major manufacturer. The major manufacturers that are looking at hybrid motors at the moment are looking at fuel cells – battery with a gasoline diesel combination," he said.

Kemp said Toyota, which has released a hybrid car, had sold about 150,000 of the environmentally-friendly model worldwide.

"But that is over several years. There is a lot of demand for that car but that is the only one that is really available and nobody knows whether Toyota is making any money out of it."

Lawmakers Target Modem Hijacking

State lawmakers in Albany, NY, have unveiled a bill that is believed to be the first in the nation to target modem hijacking, a practice in which thieves tap into people's computer modems to make international phone calls.

If passed, the law would allow telephone companies and the state attorney general to bring lawsuits against modem hijackers and their accomplices. The bill is expected to face a vote by the end of June. Other states are considering similar, broader bills, according to Pam Greenberg of the National Conference of State Legislatures.

The hijackers tap into people's modems by luring computer users to specific websites — sometimes through emails — where pop-up windows emerge inviting the user to click on them. The windows authorize the downloading of modem software that is then remotely accessed to make international calls that are charged back to the user.

"This is a new kind of thievery and it takes new kinds of law to deal with them," said Democratic Assemblyman Richard Brodsky, one

of the bill's sponsors.

Verizon has begun investigating complaints from customers thought to be victims of modem hijacking, spokesman Cliff Lee said. He said the company also advises customers how to avoid the practice through consumer alerts and bill messages.

Consumers can fight hijacking by using a dedicated phone line for the computer dial-up connection, then blocking international calls to that line. Lawmakers said people should also install a firewall to block hackers and avoid unfamiliar websites, although some hijackers masquerade behind legitimate-sounding names.

Flaw Found in Firefox

A flaw has been discovered in the popular open-source browser Firefox that could expose sensitive information stored in memory, Secunia has warned.

Firefox versions 1.0.1 and 1.0.2 contain the vulnerability, the security information company said in a recent advisory. The flaw stems from an error in the JavaScript engine that can expose arbitrary amounts of heap memory after the end of a JavaScript string. As a result, an exploit may disclose sensitive information in the memory, Secunia said.

"Unlike other browser flaws, this one is not subject to phishing or access to the system. But it can expose sensitive information from other websites you visited and the information you entered there," said Thomas Kristensen, Secunia chief technology officer.

While the flaw is only rated as "moderately critical" by Secunia, the rapid adoption of the open-source browser means that many users may be at risk. Prior to the release of version 1.0, downloads of earlier versions of the browser had reached 8 million within the first 18 months.

The Mozilla Foundation, which makes the Firefox browser, is working on a patch, and no cases have been reported, a representative for the group said.

Secunia has developed a test that allows people to see whether their system is affected by the vulnerability.

HP Earmarks $3 Million Bonus For Interim Chief

Hewlett-Packard plans to give a $3 million bonus to CFO Robert Wayman, who served as interim chief executive after Carly Fiorina was ousted in February.

In a recent filing with the Securities and Exchange Commission, HP said that the board of directors' compensation committee approved the bonus, which is to be paid "as soon as administratively practicable after May 1."

Wayman, the company's longtime finance chief, served as CEO from February 9, when Fiorina resigned, until April 1, when Mark Hurd officially started on the job at HP. Fiorina got more than $21 million in severance.

Atair Aerospace First to Demonstrate Flocking and Swarming Capabilities on UAVs

"For the first time in history, autonomous unmanned aerial vehicles (UAVs) have flown using flocking and swarming algorithms," reports Daniel Preston, chief executive and lead engineer for Atair Aerospace, Inc. (Atair AS).

"Flocking and Swarming" are two words used interchangeably to refer to modeled flight that is biologically inspired by the flight of flocking birds and swarming insects. The capability of biological systems to autonomously maneuver, track, and pursue evasive targets in a cluttered environment is vastly superior to any engineered system.

Atair AS is pioneering the development and implementation of flocking and active collision avoidance algorithms on UAVs. Atair AS' technology was first tested December 16-18 in Eloy, AZ where a fleet of five Onyx™ systems were airdropped and successfully flocked in tight formation to target. Onyx systems are autonomously guided parafoil systems (UAV gliders) designed to allow military cargo to be parachuted from high altitude and horizontal stand off and land accurately on target. Atair AS developed the Onyx systems under contract with the US Army Natick Soldier Systems Center. Onyx systems can be dropped at up to 35,000 feet altitude, autonomously glide for 30+ miles, and land on a preprogrammed target — accurate to about 150 feet.

The importance of flocking and active collision avoidance towards the application of precision resupply is critical. With this technology, multiple systems (50+) can be deployed in the same airspace, guiding to one or multiple targets without possibility of mid-air collisions.

Atair AS' inventive technology has advanced the state of the art in guidance and control systems. This technology will open the door for advanced autonomous flight capabilities on a variety of UAV platforms from fixed wing to rotorcraft, with applications from sensor and munitions delivery to surveillance.

Atair Aerospace, Inc. is a Brooklyn-based defense company dedicated to modernizing military and industrial airdrop techniques through its range of innovative autonomously guided parachute systems and UAVs. Check out their website at **www.atairaerospace.com**

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Electronics Q&A

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, comments and suggestions.

You can reach me at:

TJBYERS@aol.com

What's Up:

It's circuit month! A simple circuit for accurately measuring relay/switch contact resistance, an AC lamp flasher, and complex A/V control center. Plus, the usual 555 suspects and a PIC programmer.

Contact Resistance Revealed

Q How do I test the condition of the contacts of a 24-volt, 30-amp, sealed relay?

Dixie D.
via Internet

A There are several methods used to test the integrity and performance of relay contacts. When a relay is energized, a set of bifurcated contacts are shoved against each other. This completes the electrical circuit.

Unfortunately, it's not that simple. When the contacts first meet each other, they bounce apart, connect again, bounce again, connect, bounce ... and finally come to rest against each other. The amount of time it takes for the contacts to settle down is called, aptly enough, the settling time. This is generally measured on an oscilloscope. Settling times typically range between two and 15 milliseconds (mS).

This is all well and good, but I have a feeling you're probably more interested in the contact resistance once the bouncing has stopped, as each bounce wears away some of the contact material.

Contact resistance for a new relay ranges from less than 50 milohms to 100 milohms. At 30 amps that can be anywhere from 1.5 to three volts lost across the contacts, which is substantial at 12 volts.

As the relay ages, the contacts become pitted and the resistance increases. The best way to measure contact resistance is with a regulated power supply and a DMM, as shown in Figure 1.

The LM317 regulator is wired to output a constant current of one amp. The DMM measures the voltage across the contacts and translates it into milohms, where one millivolt equals one milohm. Typically, the meter should read 100 millivolts (mV) or less.

I'd build the circuit in Figure 1 in a plastic utility case with an aluminum cover, to which I'd mount the LM317 and use it as a heatsink. Mount the binding posts on the opposite side of the case; mount the wall wart socket on one of the ends for quick disconnect. The shielded wire "test probes" are made from shielded audio thin-cable. Note that the shield is part of the sensor return to the DMM.

The metal-film, two-watt resistor is probably available only in a five percent tolerance (Digi-Key: 800-344-4539; **www.digikey.com**), which is close enough for all but the most demanding measurements. Be aware that the wall wart is specified for a 24-volt coil. To test a 12-volt relay, replace the wall wart with a suitable 12-volt DC unit. Nothing changes with the electronics or calibration.

Contact Resistance Tester

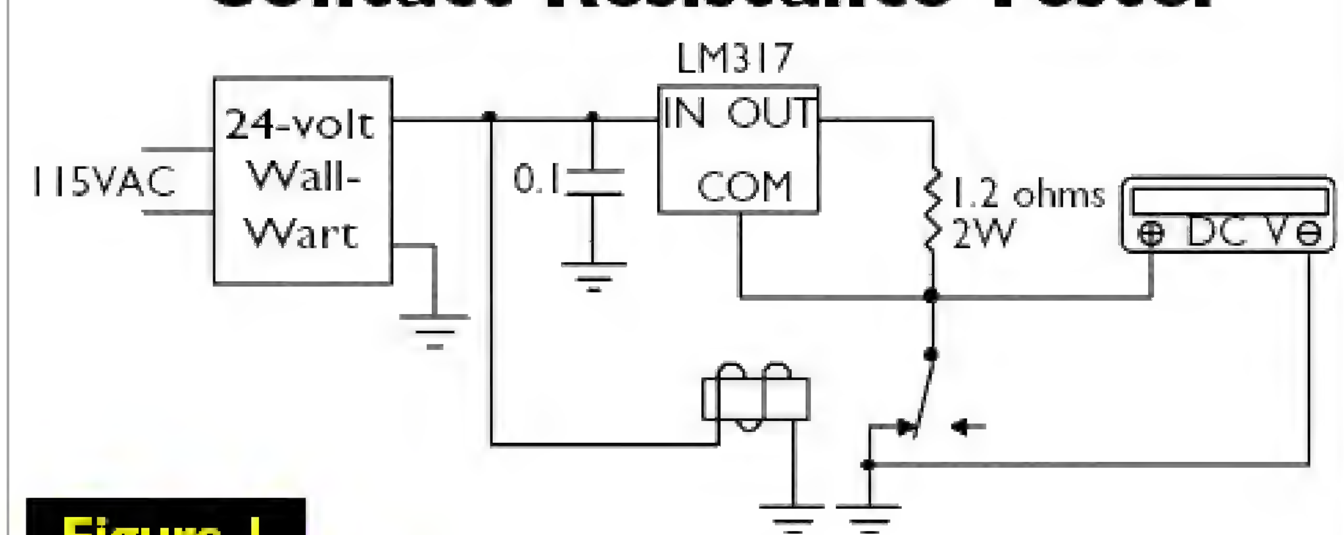


Figure 1

I Follow the Sun

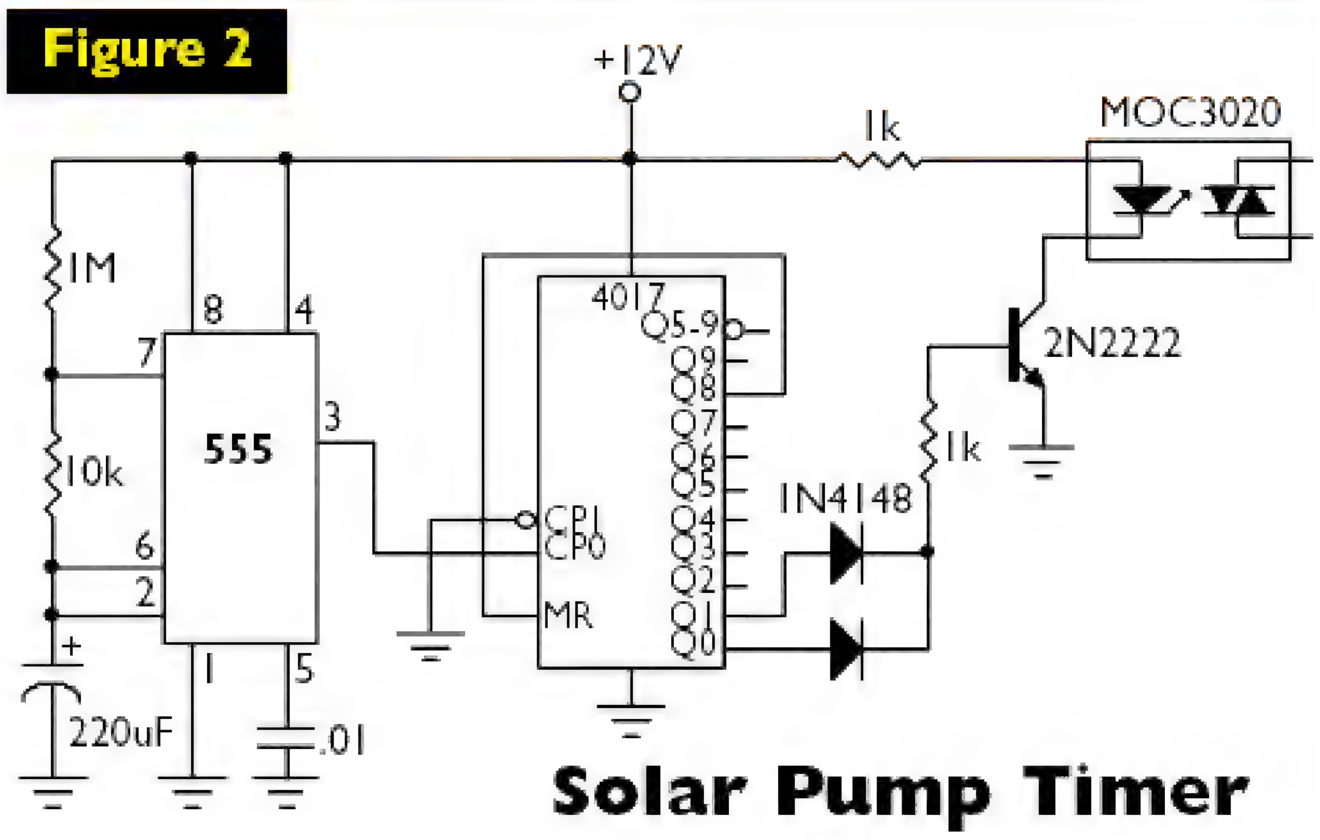
Q I have a large water-filled solar panel that tracks the sun, which I use to heat my house. I built a new controller using a 555 timer and MOC3010 coupler to control a 120-volt AC, two-amp motor. The timer should run the motor for five minutes then stop for 15 minutes, and continue cycling until evening when power is turned off. Problem is, I cannot make this controller work properly. Any ideas?

Gordon Winram
via Internet

A Yep! When power is applied to this ring counter, it starts in an indeterminate state — i.e., both timers can begin low and lock up, which is why it fails to cycle. There are ways to force a 555 power-on state, but I have a better solution: Use the 555 to pulse a 4017 decade counter as shown in Figure 2. The circuit always cycles and never stalls, even if there's a temporary power glitch.

The 555 stable oscillator generates a positive-going pulse once every 150 seconds. This, in turn, advances the output of the 4017 by one. The first two outputs (Q0 and Q1) are ORed by a pair of steering diodes to turn on the 2N2222 transistor and activate the optoisolator. On pulse number three, the Q2 output goes high, the motor turns off and stays off as the count progresses. When Q8 goes high, it resets the 4017 and starts the cycle anew.

Figure 2



Solar Pump Timer

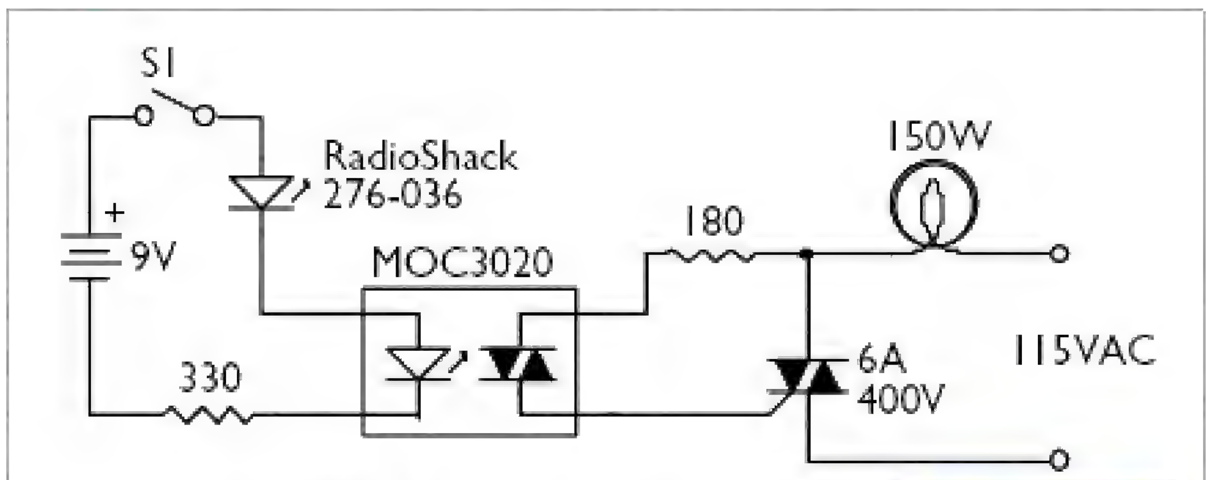
AC Line Lamp Flasher

Q To identify a live AC circuit, I would plug in a 100-watt light bulb with a button flasher. I would then measure the wires in the breaker box using a clamp-on amp meter, and look for a wire with the jumping load of about one amp. It seems that the button flashers are no longer available, plus they were only rated at 60 watts. I would like to make something that I could plug in and cause a two- to three-amp fluctuation at a rate of about once every three or four seconds. It would probably help to include a pilot light that flashed with the load.

Richard E. Woods
via Internet

A The flasher buttons that you talk about are still available — for about five bucks each. They were originally designed to flash Christmas lights, which explains their 60-watt limit. A high-power AC line flasher can be found in Figure 3.

This circuit is designed around a flasher LED, like the RadioShack 276-036. The LED typically flashes at a rate of once per second at five volts. When operated with a nine-volt battery, the rate decreases to once every other second. (The rate may vary with individual LEDs.) The flasher LED is wired in series with the LED inside an MOC3020 optoisolator, which flashes in unison. This, in turn, causes the 150-watt lamp to flash.



Lamp Flasher

Figure 3

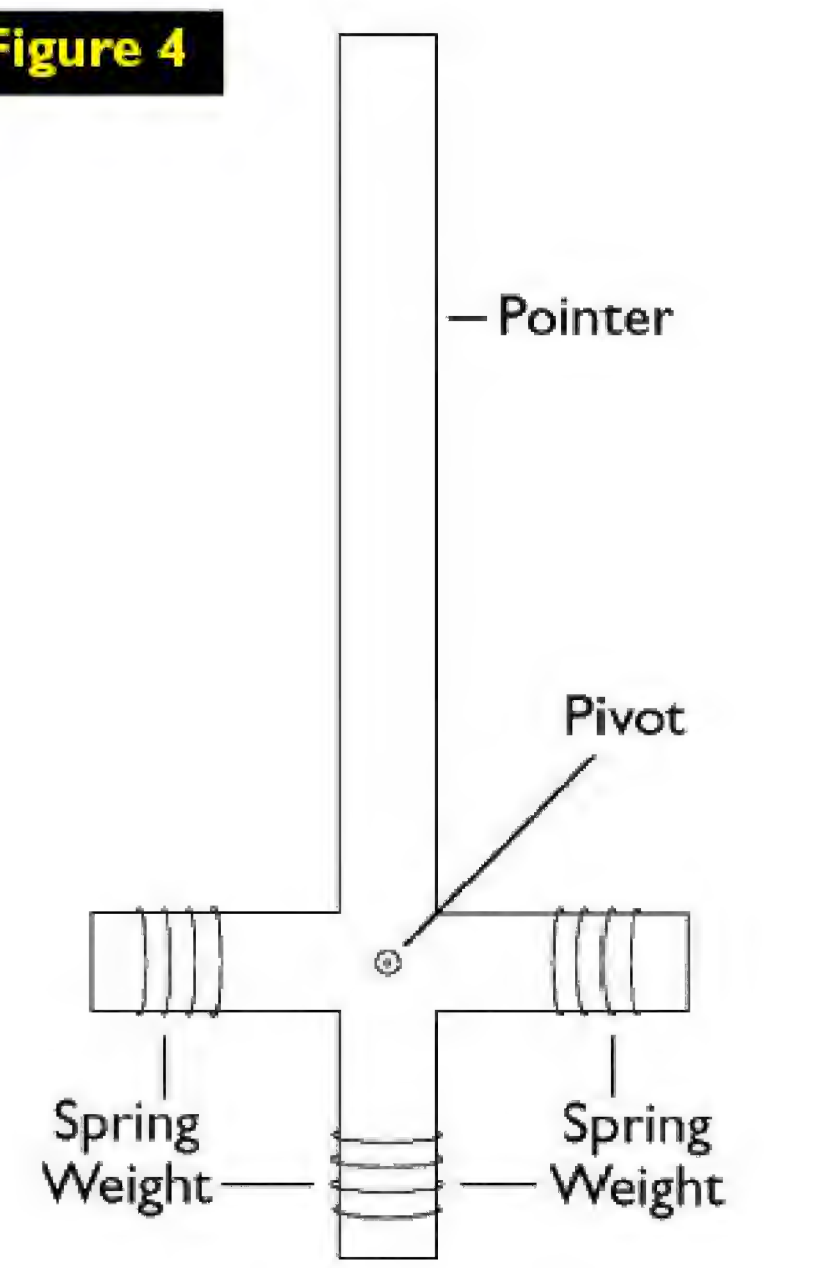
Meter Metrology

Q Some of my panel meters (milliameter and voltmeter) change the zero position depending upon being held in a vertical or horizontal position. Can this be remedied, or is this the job for a meter professional?

Richard H. Abeles
via Internet

A I assume you're talking about analog meters with a needle. Generally, the needle rests on a pivot that has to be balanced so that its weight remains the same around the pivot point (see Figure 4). Notice that the needle is actually in the form of a cross, with the pointer longer than the legs. Weight is added to the shorter legs via coiled springs that slide back and forth to change the center of gravity.

Figure 4



Analog Meter

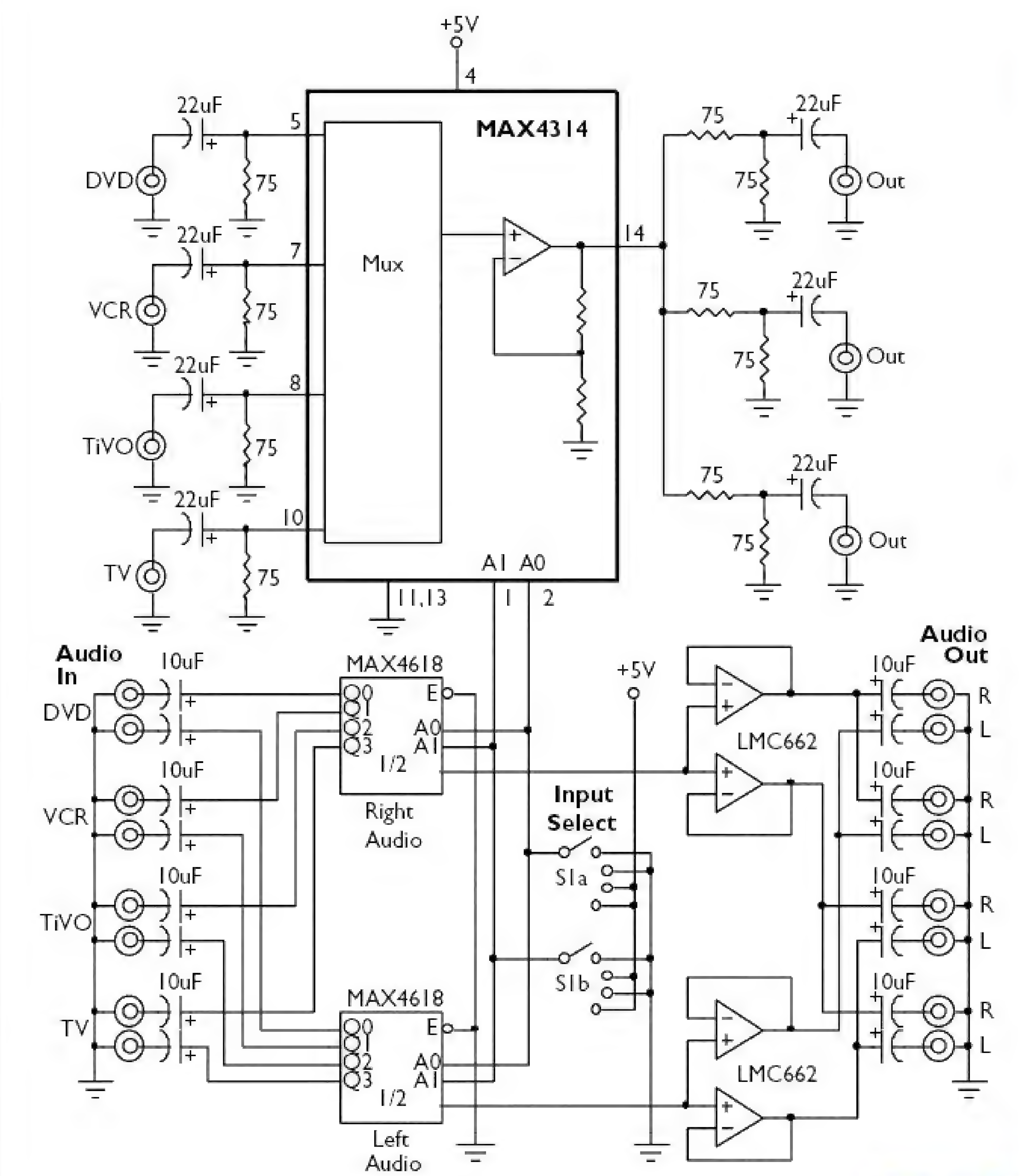
GE Thermistor Model Number	Rated Watts	Steady Amps RMS	Cold Ohms	Hot Ohms
CL-101	1840	16	0.5	.02
CL-11	1380	12	0.7	.02
CL-30	920	8	2.5	.06
CL-40	690	6	5	.11
CL-60	575	5	10	.18
CL-70	460	4	16	.27
CL-80	345	3	47	.49
CL-90	230	2	120	1.18

Table 1. Inrush Thermistor Selection Guide

However, this is a lot easier said than done. That's because everything about the movement is delicate and very fragile. One false move and you can dislodge the jewel, damage the return spring (or taut ribbon), or the needle itself. This adjustment requires a steady hand, a loop magnifier, and jeweler tools. That said ...

Start by rotating the meter in a gimbaled circle to find which axis has the off-balanced weight. This is the hardest part because if you guess wrong and move the wrong counterweight, you could be in for a long day.

Sometimes (not often) it's necessary to bend the weighted tabs up or down, but this has to be done ever so carefully. It's usually better to keep the cross on the same plane so that all the legs are flat. Also be warned that some cheap panel meters, especially iron vane meters, need to be mounted in one orientation only and have to be re-zeroed as their position changes. Good luck!



A/V Control Center

Figure 5

Plug It In, Plug It In

Q I've heard that consistently turning on and off electronic components, such as a television or computer, will create a small amount of damage to the circuitry. Because of this, it is actually better to leave these devices on all the time. Is there any truth to this?

Gene Bozek
via Internet

A What you describe is called in-rush current, and it applies to all forms of electronics. In incandescent lamps and CRT filaments, it's caused by the difference in resistance of the heating element, which has less resistance when cold than hot. Hence, there is a big surge of current followed by reduced current as the filament heats. Destructive in-rush current also applies to power supplies, where the surge current is caused by the initial charging current of the capacitors.

A fully discharged cap behaves like a short circuit when voltage is applied — current that has to be absorbed by the rectifier diodes and pass transistors. And like a hot wire, the in-rush current decreases with time.

As to leaving the electronics on or turning them off, that's a topic

for debate. While the electronic device is running, it generates heat. Heat is an enemy of electronic components and shortens their life proportional to ambient temperature. Frequent on/off power cycling of the device, on the other hand, will take its toll in in-rush current. So which to choose?

The ideal solution is to limit the in-rush current to a safe level, then operate the device for only as long as you need it. This can be done using an in-rush current limiter (ICL — a negative temperature coefficient thermistor). From he Table 1, select the correct ICL from the Steady Amps or Rated Watts columns that most closely matches your equipment requirements. ICLs can be purchased from several sources, including Digi-Key.

Audio/Visual Control Central

Q I need some sort of video switch with connectors for DVD, VCR, and TiVO, as well as the TV itself. I think an electronic switch would be best, either for Channels 3/4 RF or separate video and audio channels. It needs to be highly expandable and serve many inputs and a bunch of outputs. I see at least four inputs. Any ideas to solve this problem, even with a microprocessor to do the switching?

Tom Bohacek
via Internet

A What you describe can be done using a single multiplexer chip, like the MAX4314 (see Figure 5). It can handle four inputs that are individually selected by binary code on the A0/A1 address lines. The number of inputs can be increased to eight by replacing the chip with a MAX4315.

The chip can drive several loads, but I suggest using a transconductance voltage-follower (like the MAX436) if you need more than four outputs. The audio channels are selected in the same way using MAX4618 analog switches. It, too, can be expanded by adding more switches to the mix.

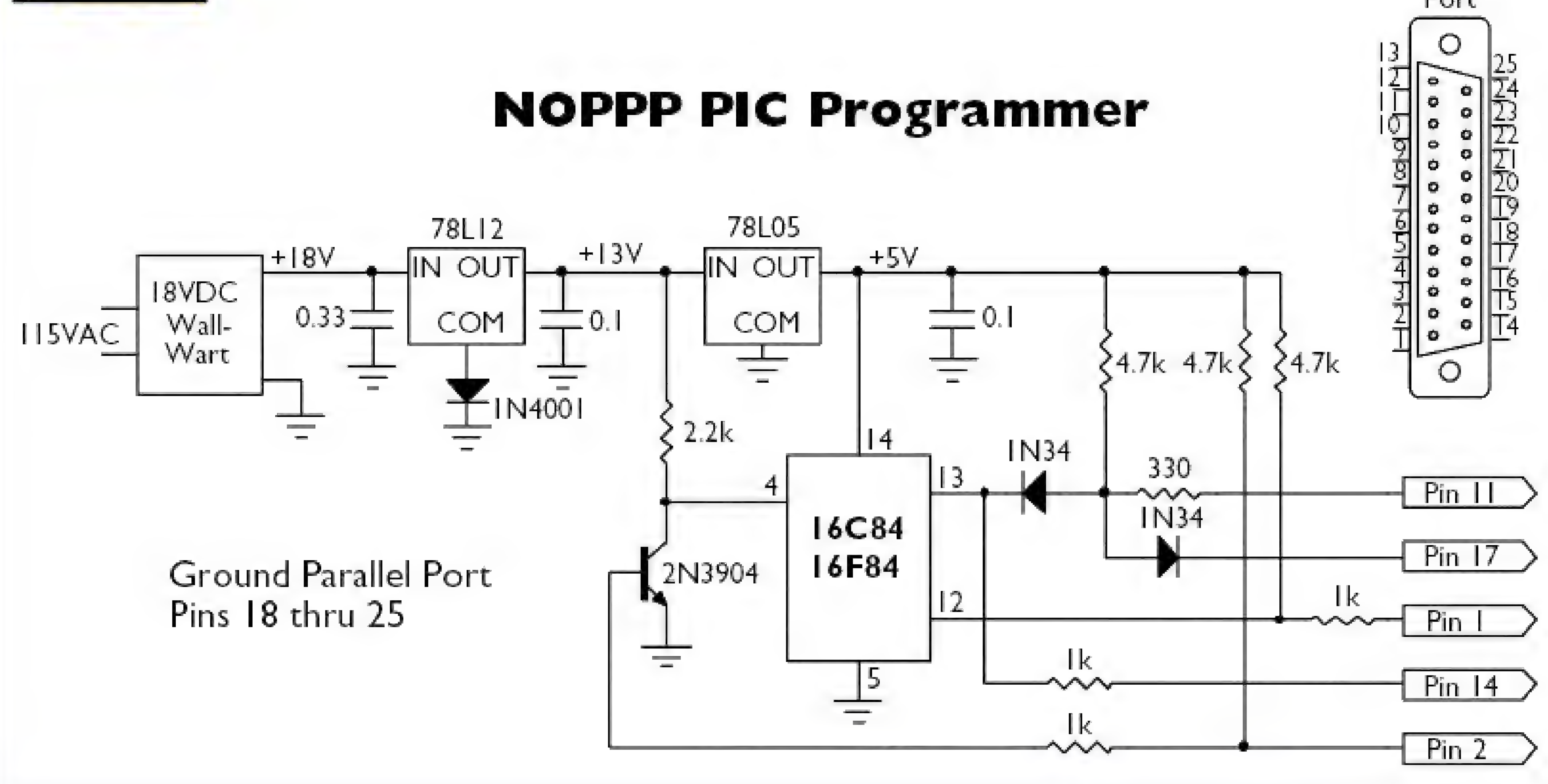
PIC Programmer ... Again

Q If the 555 and the 741 are the most common and popular universal ICs in the world, what is the most common PIC chip in the world? In a DIL package, please. Also, I was wondering where can I get the software and the schematic for a programmer?

Raymond
via Internet

A The 16C84 and 16F84 are by far the most popular PICs. Other

Figure 6



popular choices are the 12C508, 12C509 and — my personal favorite — the 16F628. My choice for a DIY PIC programmer is the NOPPP created by Michael A. Covington (see Figure 6). You can find a zip file of the NOPPP project, including software, on our website (**www.nutsvolts.com**) under the name NOPPP.ZIP.

Cool Websites!

Hacking your mouse.
http://nl.internet.com/ct.html?rtr=on&s=1,1g8l,1,mbeq,a3ot,3qmh,cu1s

The Web, 60 Years Ago
Vannevar Bush laid out a passionate vision of an "information appliance" of the future. Looking back, we find a remarkably prescient description of what we today call the World Wide Web.

http://nl.internet.com/ct.html?rtr=on&s=1,1f72,1,2242,3jkk,3qmh,cu1s

Surfing the Internet to find replacement computer or laptop parts? SparePartsWarehouse has re-launched its website to make it easier to find obscure and readily available PC parts.
www.sparepartswarehouse.com

MAILBAG

Dear TJ,

In the September 2004 issue ("Project Needs PIC Burner"), you mention the source file as being computer-ese. I believe it would be more appropriately called a limited set of unambiguous English statements or perhaps human-ese. These English statements must be translated into ones and zeros before the processor can execute them. In the interest of saving beginning programmers a lot of anxiety, it would be nice if you clarify your comments in the article.

Nels Overgaard
via Internet

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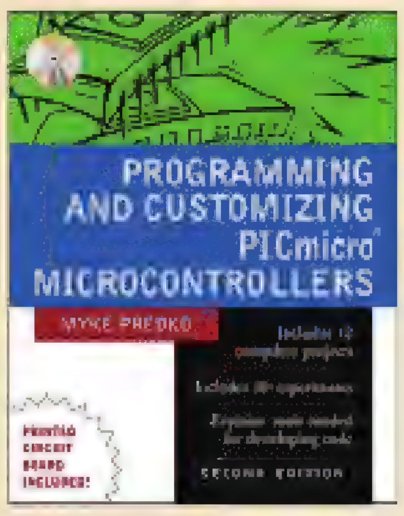
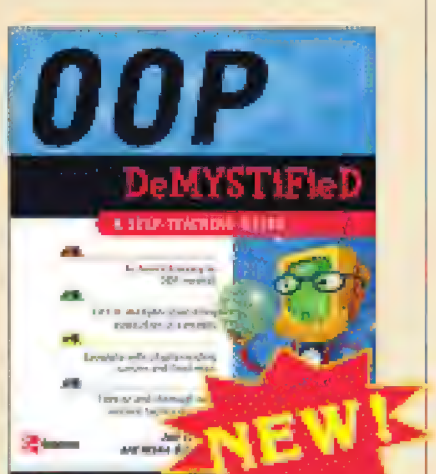
Microcontrollers

Programming & Customizing PICMicro Microcontrollers
by Myke Predko



This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicros' hardware architecture and software schemes will complement the host of experiments and projects making this a true "learn as you go" tutorial. New sections on basic electronics and basic programming have been added for less sophisticated users, along with 10 new projects and 20 new experiments. The CD-ROM contains all source code presented in the book, software tools designed by Microchip and third party vendors for applications, and the complete data sheets for the PIC family in PDF format. **$49.95**

OOP Demystified
by James Keogh / Mario Giannini



Learn object-oriented programming in no time with help from this easy-to-understand guide, ideal for novice and expert programmers alike. Learn about attributes and methods, inheritance, polymorphism, real-world and case modeling, object-oriented programming languages, and much more. Each chapter ends with a quiz, culminating in a final exam at the end of the book so you can test your knowledge. **$19.95**

Programming & Customizing the 8051 Microcontrollers
by Myke Predko

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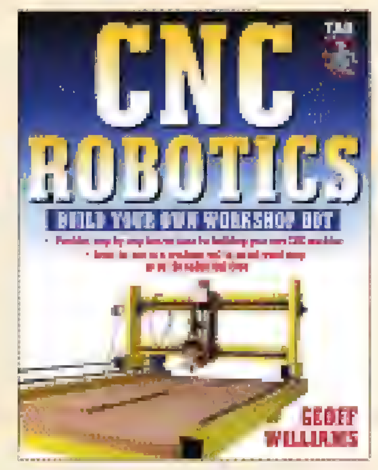
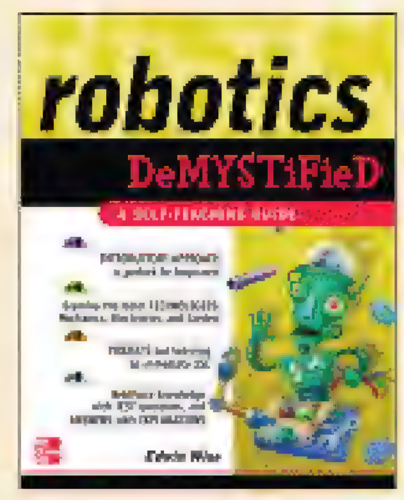
Robotics

CNC Robotics
by Geoff Williams



Written by an accomplished workshop bot designer/builder, *CNC Robotics* gives you step-by-step, illustrated directions for designing, constructing, and testing a fully functional CNC robot that saves you 80% of the price of an off-the-shelf bot — and can be customized to suit your purposes exactly because you designed it. **$34.95**

Robotics Demystified
by Edwin Wise



McGraw-Hill's *Demystified* titles are the most efficient, interestingly written brush-ups you can find. Organized as self-teaching guides, they come complete with key points, background information, questions at the end of each chapter, and even final exams. This complete self-teaching guide takes an introductory approach to robotics, guiding readers through the essential electronics, mechanics, and programming skills necessary to build their own robot. **$19.95**

Open-Source Robotics and Process Control Cookbook
by Lewin Edwards

In this guide, Lewin Edwards demonstrates efficient and low-cost open source design techniques, covering end-to-end robotic/process control systems using Linux as the development platform, with extensive information on free compilers and other tools. Specifically, the book targets development of real-time physical system controls using Atmel AVR microcontrollers communicating with Linux-based PCs for overmonitoring. Code examples are given to provide illustrations of tasks described in the text. The CD-ROM contains all the code used in the design examples, as well as useful open-source tools for robotics and process control system design. **$49.95**

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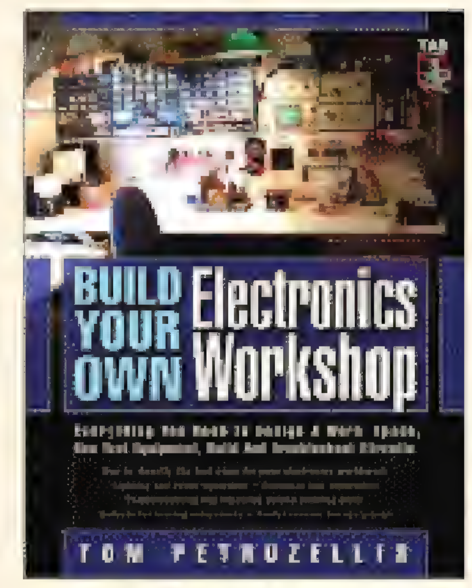
Electronics

Build Your Own Electronics Workshop
by Thomas Petruzzellis



The Electronics Workbench was created to assist the newcomer in the field of practical electronics through the creation of a personal electronics workbench. It is a place specially designed so that readers can go there to work on an electronic project, such as testing components, troubleshooting a device, or building a new project. The book includes invaluable information, such as whether to buy or build test equipment, how to solder, how to make circuit boards, how to begin to troubleshoot, how to test components and systems, and how to build your own test equipment, complete with appendix & resources, etc. This is *THE* book for anyone entering the field or hobby of electronics. **$29.95**

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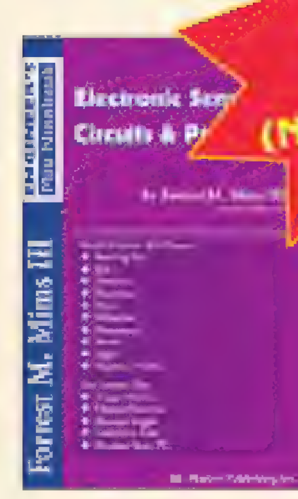

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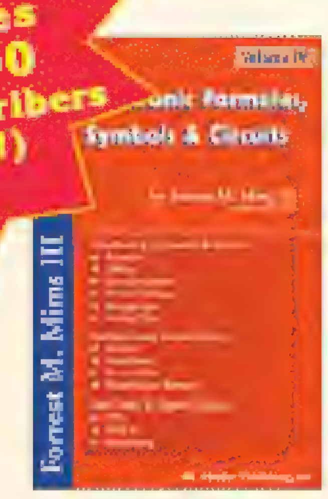

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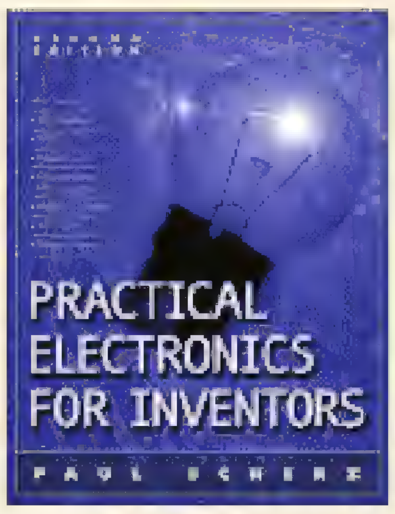

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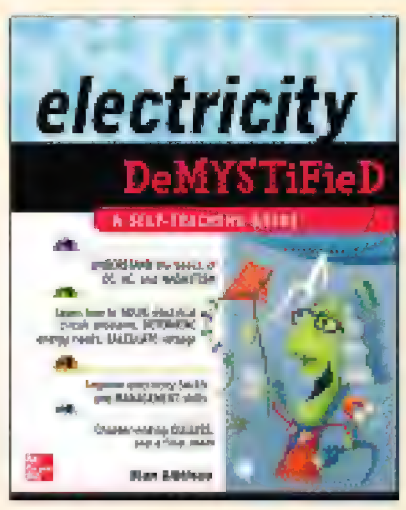

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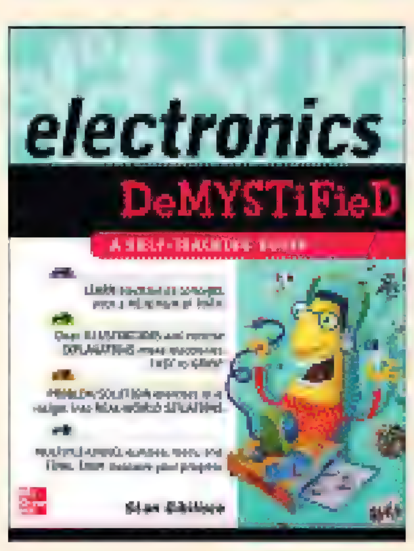

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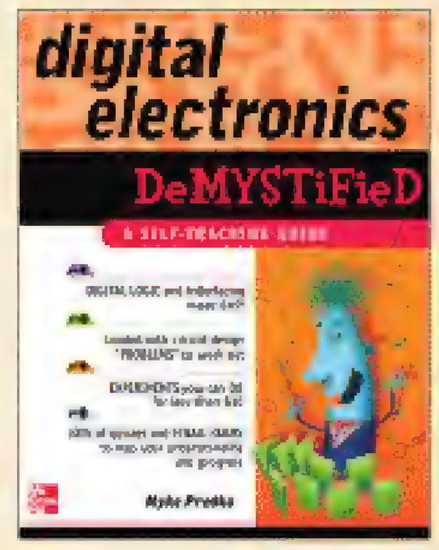

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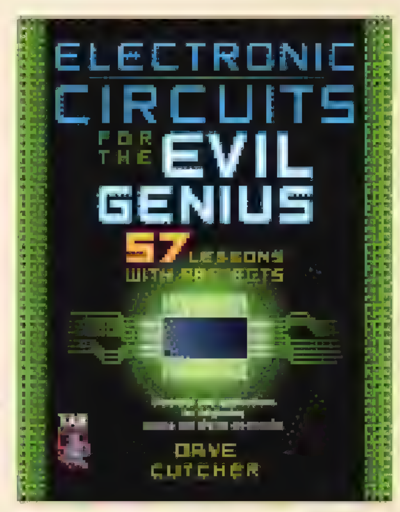

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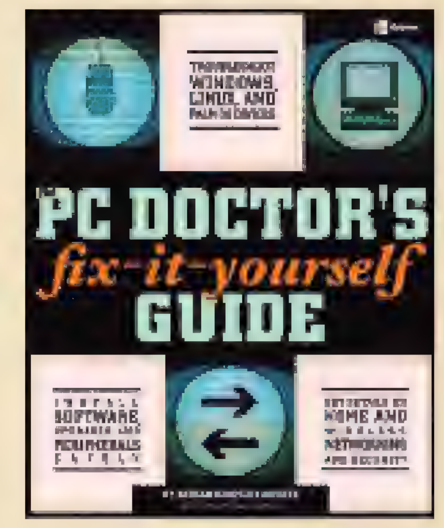

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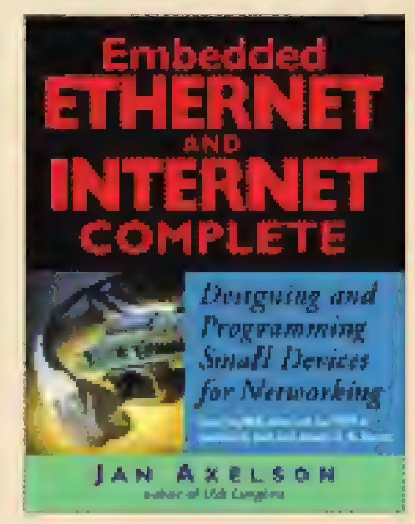

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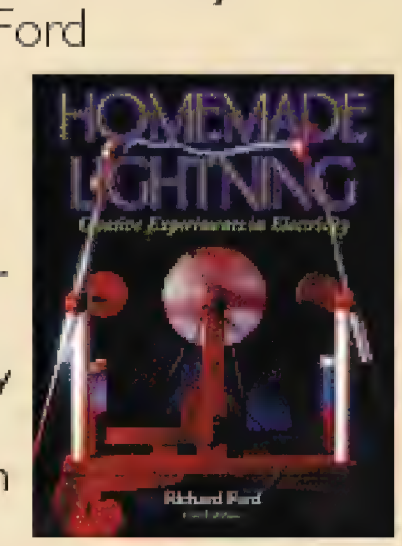

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by Andy Sullivan

In the Blink of an Eye

Stop-Action Photography With a Strobe Light

This Month's Projects

The Fuzzball Rating System

To find out the level of difficulty for each of these projects, turn to Fuzzball for the answers.

The scale is from 1-4, with four Fuzzballs being the more difficult or advanced projects. Just look for the Fuzzballs in the opening header.

You'll also find information included in each article on any special tools or skills you'll need to complete the project.

Let the soldering begin!

In an otherwise dark room, a short flash of light is used to capture the stop-action photos you see on the pages of this article. The short duration of the flash is what provides the stop-action, and a strobe tube can produce a flash duration of about 1/1,000 of a second. This is fast enough to capture still images of exploding objects and events of similar velocity.

A simple strobe circuit and an ordinary camera can be used to produce stop-action photos that are otherwise too quick for the naked eye to see. Examples include a light bulb shattering with shards suspended in midair or a balloon bursting with fragments caught in still motion.

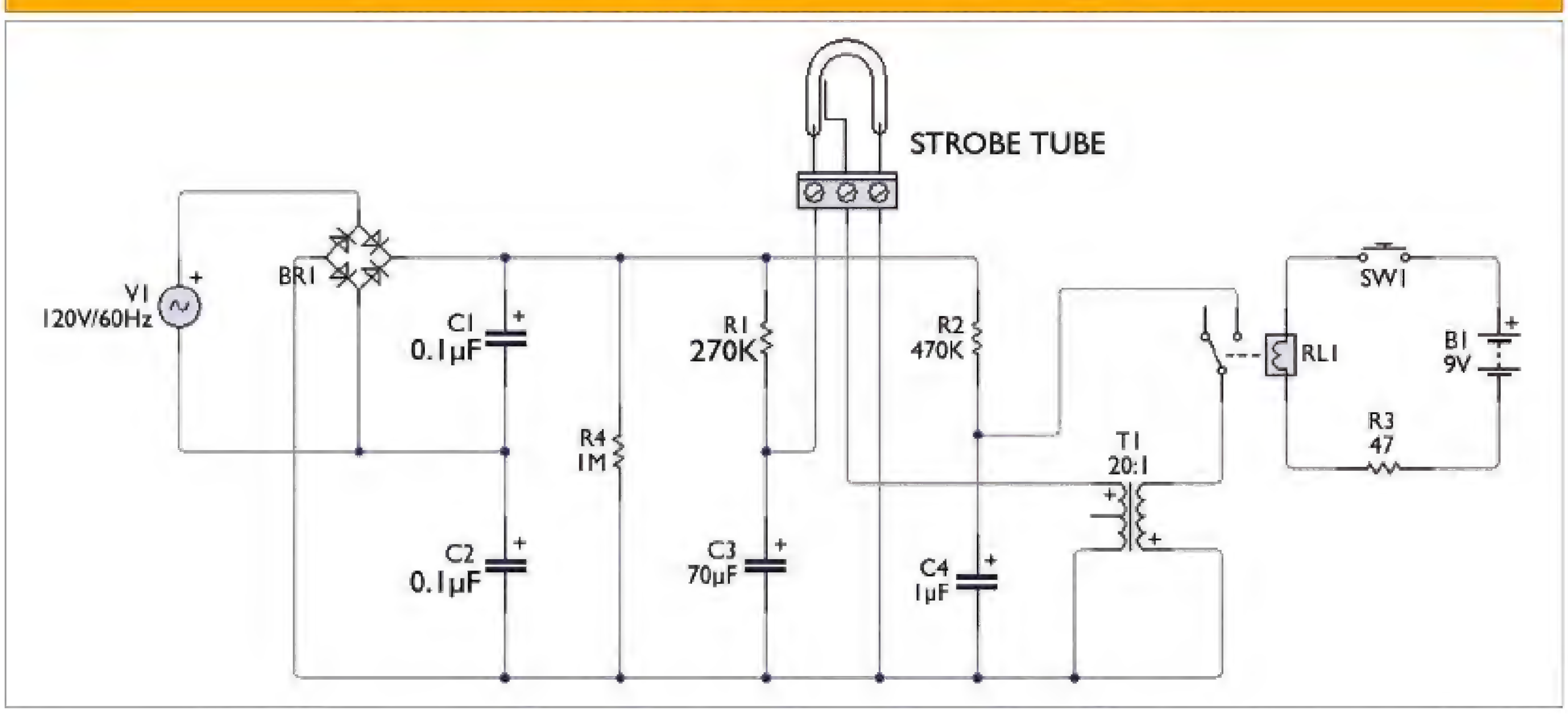
The technique used to take the photographs is simple. A camera is set up on a tripod focused on the event to be photographed. The camera's timer is set to provide a several-second delay between when the button is pressed and the shutter opens. This feature is normally used to allow you (or your assistant) to get into the picture, if necessary. When the button is pushed, you move into position to trigger the event to be photographed. This might be to position yourself near a BB gun trigger or other such device to be activated. Once positioned, you can turn off the lights, and after the camera's shutter opens, trigger the event. The strobe is triggered automatically, and the image is exposed. When the camera shutter closes, turn the lights back on and you are ready to take another shot.

An ordinary camera is all that is required to capture the images shown in this article. I have used both 35mm and digital cameras, but whatever camera you use, it will need to have an adjustable shutter speed. A long shutter speed gives time to trigger the event when the shutter is open. Shutter speed for a typical everyday-type photograph might be 1/125 of a second, too fast to respond to. A setting of one to four seconds gives plenty of time to hear the shutter open and pull a BB gun trigger before the shutter closes.

An external strobe light is used to expose the image because we can use an external mechanism to trigger the flash. Two pieces of aluminum foil that make contact when a BB passes through makes a good trigger. Most cameras come with integrated flash units that cannot be externally triggered.

[Caution: As Mr. Sullivan will later explain, if you are using a BB gun for this project, make sure to wear eye protection at all times and to create a backboard that will absorb the BB after it has penetrated its target. A block of Styrofoam will help

Figure 1. The circuit schematic for the strobe and trigger switch.



keep the BB from ricocheting around the room.]

Full-Wave Bridge / Voltage Doubler

The circuit schematic is shown in Figure 1. The voltage needed to drive the strobe tube is developed by a bridge-doubler circuit powered by wall current. The bridge-doubler utilizes a full-wave bridge and two capacitors to rectify the input AC voltage to DC and to double it.

The wall voltage needed to supply the circuit is 120 volts AC, and the 120 volts is an average value over the alternating current cycle. Peak voltage in the cycle is 170 volts, and the voltage-doubler circuit will double the 170-volt value and produce a DC voltage of 340 volts. For more information on peak versus average voltages in AC circuits, look up root mean square (RMS) voltage on the Internet.

The full-wave bridge should be rated for twice the input voltage, 340 volts or greater. I chose a bridge rated for 400 volts and three amps which has plenty of capacity for this circuit.

The two capacitors adjacent to the bridge in the circuit should also be rated for twice the input voltage. The capacitors have to be large enough to smooth the output voltage from the bridge, and 0.1 µF works well in this case. If it is too small, the bridge output voltage will have a significant oscillation which will lower the effectiveness in charging the main capacitor. Capacitors too large, however, are unnecessary and will store excess hazardous energy.

Main Strobe and Capacitor Circuit

To produce a stop-action photograph, the flash tube must produce enough light to expose the shot in a very short duration. This high-intensity light is produced with a flash tube, and the energy needed to power the tube is charged in a large capacitor.

The strobe tube selected for this project has a rated flash energy of four joules (watt-seconds). The following equation for energy stored in a capacitor is used to determine the size of capacitor needed. U is energy in joules, which, in this case, is four for the strobe selected, while V is 340 volts for this circuit. Solving for capacitance, C, yields 0.000069 farads or about 70 µF.

$$U = \frac{1}{2} CV^2$$

A resistor is placed in series with the capacitor in the circuit for two reasons: First, it will limit the current to the capacitor when charging, which could be excessive. Second, it will provide a slow-charging circuit so the strobe light will quickly discharge the capacitor and go out. If there was no resistor, the bridge circuit could keep the strobe illuminated once triggered, damaging the tube and failing to produce a short flash.

Figure 2. The complete strobe assembly.

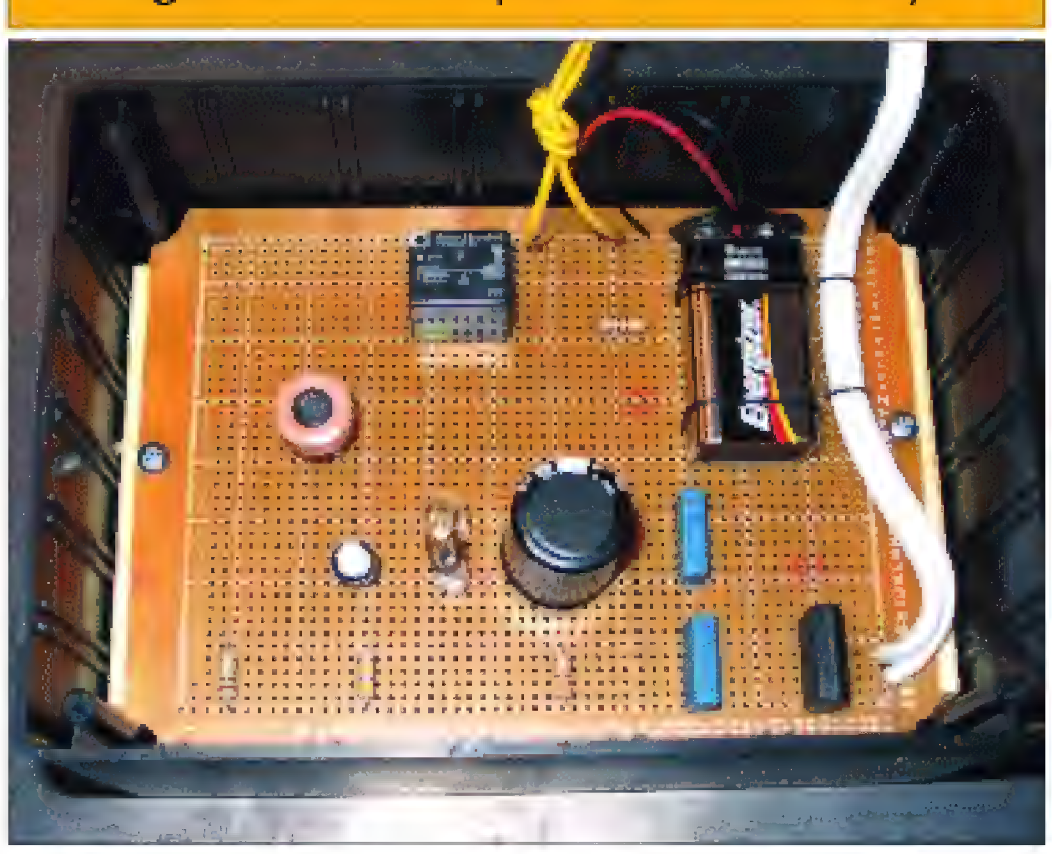
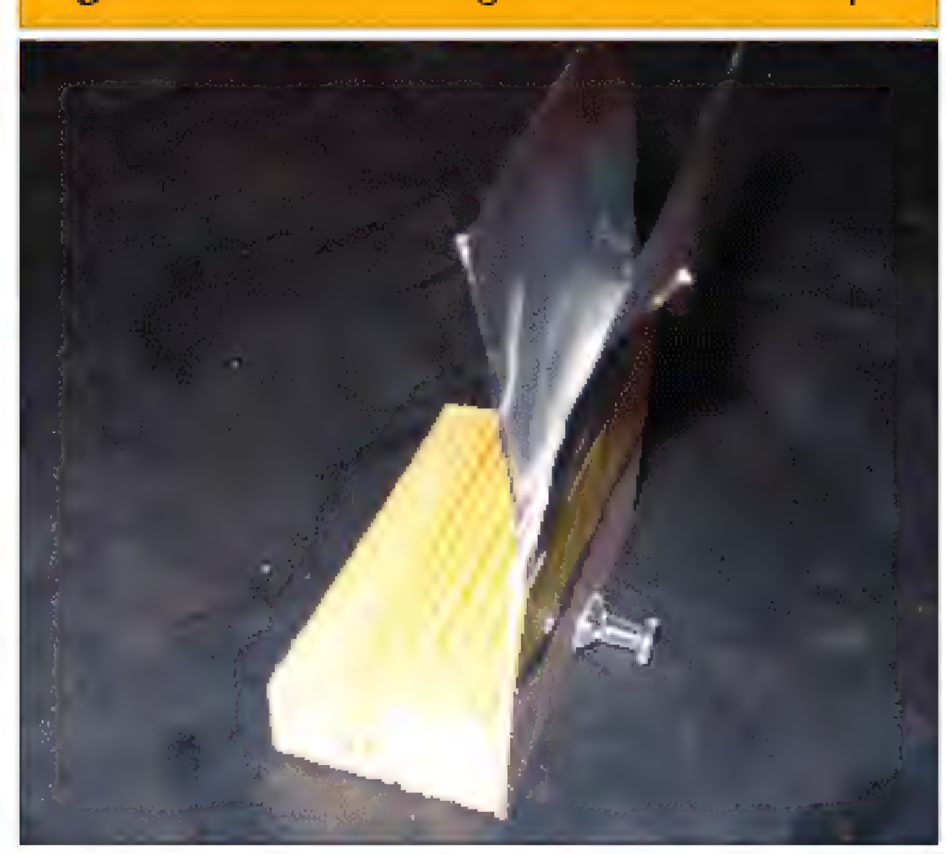


Figure 3. Constructing the switch is simple.



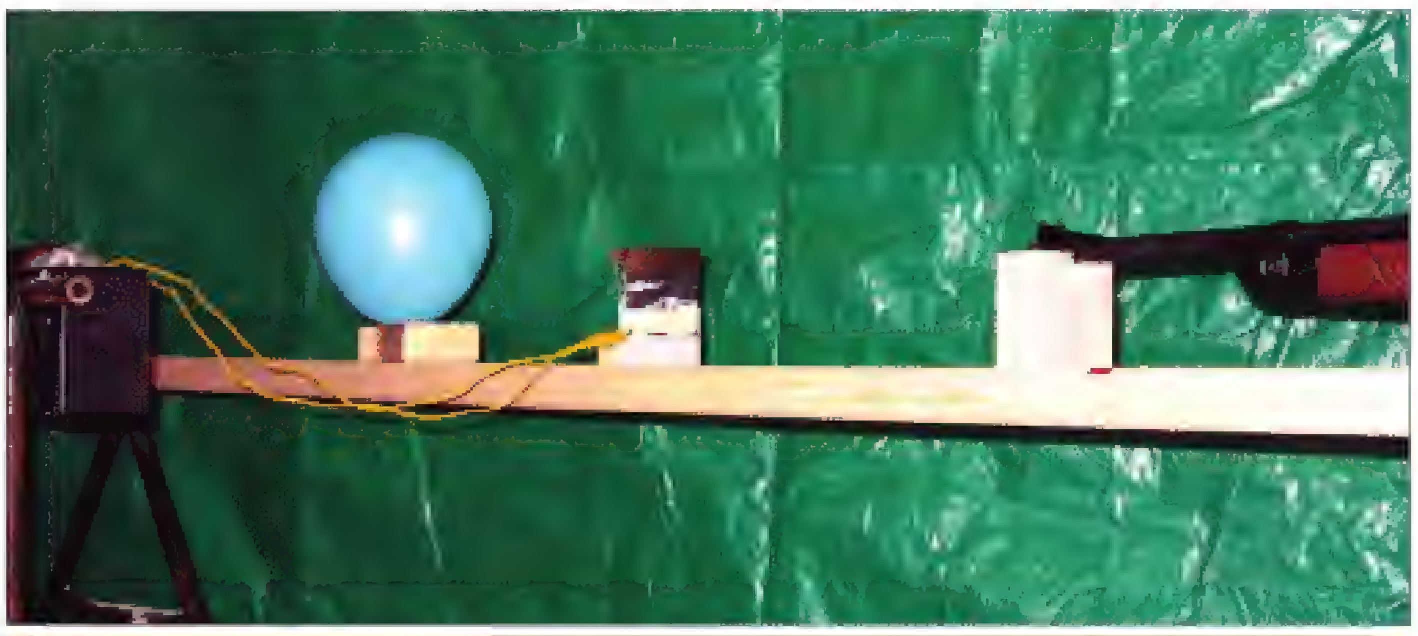


Figure 4. The completed setup.

The resistor is sized to yield a suitable charge time so it does not overload the resistor. During initial charging in an RC circuit, maximum current will flow through the resistor with full voltage across it. Using the power law shown below, resistance can be determined which will yield a 0.5-watt power consistent with a typical resistor, so solving for resistance, R, where V is 340 volts and P is 0.5 watts, yields 231,200 ohms. This value is close to a common resistor value of 270 kilohms which is used in this circuit.

$$P = \frac{V^2}{R}$$

Charging time for the circuit is determined using the RC/time constant. The RC constant for this circuit is (270,000 ohms) x (0.000070 farads) = 18.9 seconds. An RC circuit charges to 40 percent of full charge in one time constant, 75 percent in two time constants, 90 percent in three time constants, and 96 percent in four time constants. So, this circuit will essentially be fully charged in four time constants, or one minute and 15 seconds.

This circuit takes advantage of a capacitor's ability to quickly deliver its stored energy, and the total energy per strobe flash is four joules. A strobe can deliver this energy in about 1/1000 second. Power is energy per unit time, or four joules per 1/1000 second. This energy rate is 4,000 joules per second, or 4,000 watts. That is equivalent to 40 100-watt light bulbs all going off at once.

So, for that brief fraction of a second, this circuit will provide more power than your home uses with all the lights, appliances, and everything else turned on all at once, including the dryer, oven, and air conditioner.

All the capacitors in the circuit must be discharged and double checked before any work on the circuit is done. *The voltages and energies involved in this circuit are potentially lethal, just like any other wall-outlet-powered device.* The capacitors present the additional hazard of stored energy, so to help mitigate this hazard, a one-megohm resistor is connected between the hot and ground side of the circuit. This resistor is in series with the 270-kilohm resistor on the main capacitor.

Once the circuit is unplugged, it will take six minutes to discharge the main capacitor 96 percent of the way, so the case must not be opened for at least six minutes after being unplugged. Because any safety device has the potential to fail, you must confirm the capacitors are discharged as you carefully open the case.

Trigger Circuit

When the main capacitor is fully charged, there are 340 volts across the leads of the strobe tube. Current will not flow through the tube because the xenon gas is not conductive at normal conditions. To trigger the flash, the xenon gas will be ionized into a conductive plasma by subjecting the gas to a 6,000-volt electric field. The 6,000 volts will be delivered as a brief pulse to a conductive strip or wire on the outside of the strobe tube. The electric field developed by the pulse of high voltage is sufficient to rip electrons from the xenon atoms inside the tube making a plasma. The plasma is conductive, and the energy stored in the main capacitor will discharge through the strobe tube and generate the flash.

The high-voltage trigger pulse is developed with a 20-to-1 trigger coil. The primary coil is energized with a small capacitor charged to 340 volts. Since only a small capacitor is needed to drive the trigger coil, a one-µF capacitor was selected. A resistor is used here again to control high surge currents when charging the capacitor and to prevent excessive currents through the trigger primary. A 470-kilohm resistor was selected which will limit currents to about one mA. The RC time constant for the trigger capacitor is 0.5 seconds, so it will fully charge in a couple seconds.

Figure 5. View as the balloon is exploding.

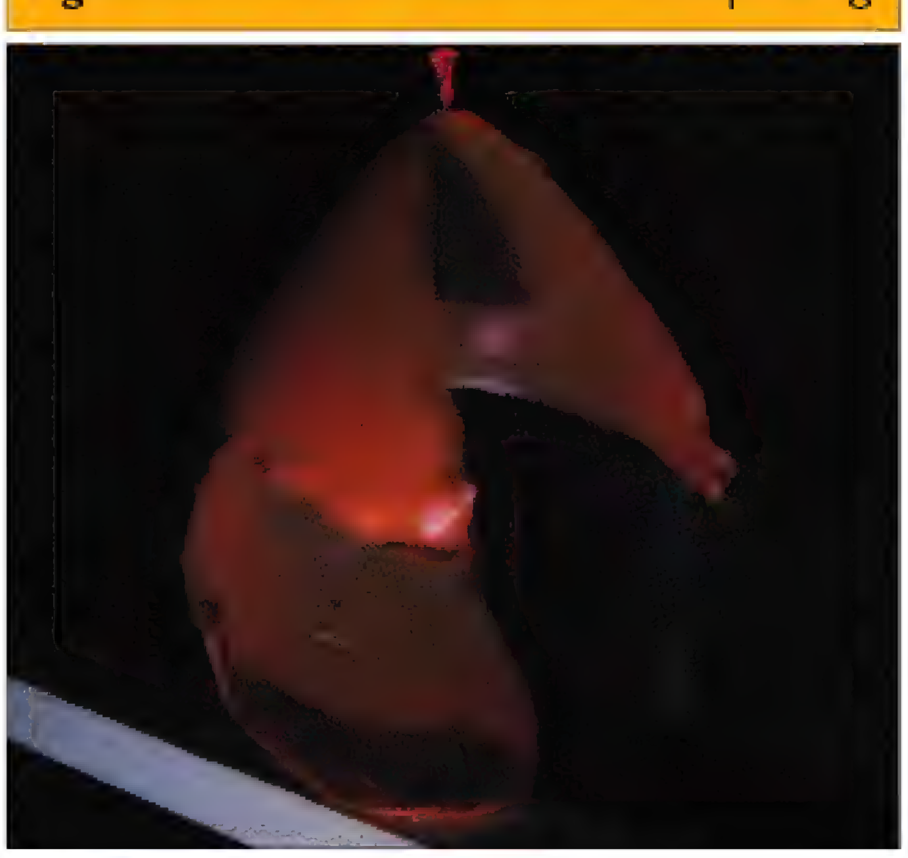


Figure 6. A BB hitting a light bulb.

A switch is needed to route energy from the trigger capacitor to the trigger coil primary, so a mechanical relay was selected which will use a low-voltage signal to close the high-voltage trigger circuit. Isolating the high voltages from the signal circuit is an important safety consideration to prevent accidental contact with the 340 volts in the trigger circuit.

There is an eight-millisecond time delay to close the mechanical relay based on its datasheet. This time delay is fast enough for the photographs discussed here, but a faster

circuit may be required for some situations. Solid-state alternatives to the relay were tested, including optically isolated silicon-controlled-rectifier (SCR) and TRIAC (three-terminal semiconductor) circuits, but elegant solutions for handling the higher voltages were not found. Some readers may have good ideas on how to design a superior trigger circuit.

The low-voltage control side of the trigger relay is simply a nine-volt battery. It features two wires that leave the circuit and hook to an external switch and a resistor to control relay coil currents. The relay used is a five-volt relay with a 70-ohm coil. Coil current is therefore about 71 mA. A 56-ohm resistor is required to drop the nine volts to the nominal five-volt relay voltage. A 47-ohm resistor was selected based on availability. Relay voltage increases to 5.3 volts with the smaller resistor, but it is well within the coil specs.

Strobe Assembly

The circuit was assembled in a 7 x 5 x 3-inch project box on a 4-1/2 x 6-1/8-inch pre-drilled PC board. Connections were point-to-point wired and soldered. To protect a user from the high voltages across the strobe tube, the entire circuit was placed inside the box and a plexiglass cover was cut to fit. The only wires leaving the box are the 120-volt cord to the wall socket and the low-voltage leads from the control side of the trigger relay. A photograph of the complete strobe assembly is shown in Figure 2.

Setup

Setup to take the stop-action photos must be in an area that can be made completely dark. If the objects in your photo are to be shattered with projectiles, the location must be chosen where the shards will do no harm, and there must be a means to control the projectile. A shooting range would be ideal at night time, and a low-power BB gun is recommended. Eye protection must always be used to protect from a ricocheting BB or shard. Low-energy experiments with a BB gun can be conducted inside as long as an effective BB stop is used and all attendants wear proper safety equipment.

An easy way to use a BB gun is to mount the gun on one end of a 2 x 4 piece of lumber using notched pieces of wood. The 2 x 4 provides a stable base for objects to be shot.

The trigger switch to fire the strobe light will close when the BB passes by. A simple method to construct the switch is with two pieces of aluminum foil taped to a 2 x 3-inch piece of cardboard as shown in Figure 3. Cut the foil in 3 x 3-inch pieces and tape them so they extend about two inches above the cardboard. Tack the cardboard to another piece of wood and place it so the BB will pass through the foil but not the cardboard. Attach the two wires from the low voltage side of the trigger relay to the foil sheets. Make sure the foil sheets do not touch. When the BB passes through the foil, it will push the sheets together and trigger the flash.

You can experiment with the best location for the foil switch. Closer to the BB gun yields a photograph of the object sooner after being hit. Because the strobe circuit has a delay, you may want the trigger between the BB gun and the object.

Camera Options

The photographs presented in this article were taken with a Canon PowerShot A75, a good little camera available on Amazon for $170.00. Any camera that can be set up as discussed in this article should work. I've used a 35mm camera in the past, but waiting to get the shots developed makes digital more convenient. Set the self-timer function on your camera to 10 seconds, as this will allow you to push the camera button while giving you enough time to move to the gun for firing. Manually set the shutter speed to approximately four seconds. This allows you time to hear the shutter open, pull the BB gun's trigger, have the strobe expose the image, and close the shutter. Because the shot will be taken in complete darkness, only the strobe flash will expose the image. Having the shutter open a long period of time does not impact the image, it only gives you more time to trigger the event.

You may need to adjust the amount of light to expose the image properly. You can do this by moving the strobe closer or further from the object photographed. You can also adjust the aperture on the camera. An aperture of F4.0 is a good starting point, and the larger the number,

Figure 7. A BB hitting a glass bulb filled with water.

Figure 8. With this project, the results will always be different.

the less light will enter the camera's lens to expose the image. The camera's flash should be turned off because the image will be exposed using the strobe you built.

Place the camera on a tripod and adjust it to photograph the object to be struck. The last item to add to the setup is a lamp or flashlight to be placed near the BB gun. A photograph of the completed setup is shown in Figure 4.

Taking the Photo

Use the following procedure to take a photograph once setup is complete.

1. Plug in the strobe and let it charge (75 sec. is needed).
2. Anyone present must put on safety goggles (this is the most important step).
3. Clear the area and the line of fire.
4. Load the BB gun.
5. Activate the camera (10 seconds to photograph).
6. Position yourself at the BB gun.
7. Turn off all lights.
8. When the camera shutter opens, pull the trigger.
9. When the shutter closes, turn the lights back on.
10. Unplug the strobe.

Results

Figure 5 shows a balloon as it is exploding. Note that the BB can be seen as a short golden streak at about the center of the balloon.

Fine-tuning the position of the trigger was the key to capturing a good bursting-balloon shot. I used a Crosman BB gun pumped three times for all the shots. The trigger positioned about 18 inches before the balloon seemed to work best, but balloon shots are challenging because the explosion is so fast that if you are a little off on the position, you'll miss it.

Figure 6 shows a light bulb being hit by a BB. Almost a dozen sparks can be seen leaving the bulb. Light bulb shots are challenging with a BB gun because the bulb tends to have a hole blown through it rather than explode. Small round clear bulbs seem to work best, and placing the trigger about seven inches after the bulb seemed to work well.

Figures 7 and 8 are some of the most interesting. They are hollow glass balls from holiday ornaments filled with water. Like the light bulbs, a BB gun seems to just poke a hole in the empty glass bulb. Filling it with water helps to explode the bulb and adds a splashing effect. You can see the cap to the ornament in Figure 8. Both figures shows shards of the red ornament in the splash, as the triggers are about 18 inches behind the ornaments.

Closing

Strobe photography provides a method to see events from a completely new perspective. Balloons popping and glass breaking are common occurrences in our everyday lives, but the images seen in a stop-action photograph are unexpected. The time needed to take these photographs is not long, as the circuit can be made in a day by an amateur. Setting up the flash, camera, and BB gun will take another day. All the pictures presented here were taken on the third day. **NV**

Parts List

Quantity	Description	Vendor	Mfr. Part #	Price
2	0.1-µF, 400-volt electrolytic capacitors	Digi-Key	B32652A4104J	$0.51
1	1-µF, 400-volt electrolytic capacitors	Digi-Key	UVR2G010MPD	$0.31
1	70-µF, 400-volt electrolytic capacitors	Digi-Key	EET-ED2W680BA	$3.23
1	1-megohm, 1/2-watt resistor	RadioShack	271-306	$6.29
1	470-kilohm, 1/2-watt resistor	RadioShack	271-306	$6.29
1	270-kilohm, 1/2-watt resistor	RadioShack	271-306	$6.29
1	47-ohm, 1/2-watt resistor	RadioShack	271-1105	$0.99
1	Xenon flash tube, four watt-second (joule) 200- to 400-volt, four-kv/min trigger	Mouser	361-4425	$5.85
1	High-voltage trigger transformer. 300 volts in, 6000 volts out	Mouser	422-3306	$2.79
1	Full-wave bridge, four amps, 400 volts	RadioShack	276-1173	$2.49
1	Five amps at 120VAC miniature power PC boardrelay, five VDC coil voltage	Mouser	T7CS5D-05	$1.27
1	Nine-volt battery lead	RadioShack	270-325	$1.99
1	7x5x3-inch project enclosure	RadioShack	270-1807	$5.99
1	Grid-style PC board—2,200 holes	RadioShack	276-147	$4.29

Circle #36 on the Reader Service Card.

The Computer Geek's Ultimate Timepiece

Build a Binary Clock With a Battery Backup

If you want a clock that really attracts attention, this unusual project will be a big hit. It's easy for any self-respecting computer geek to figure out how to read this clock in a few minutes, but others will simply be baffled by what seems to be a random pattern of lights.

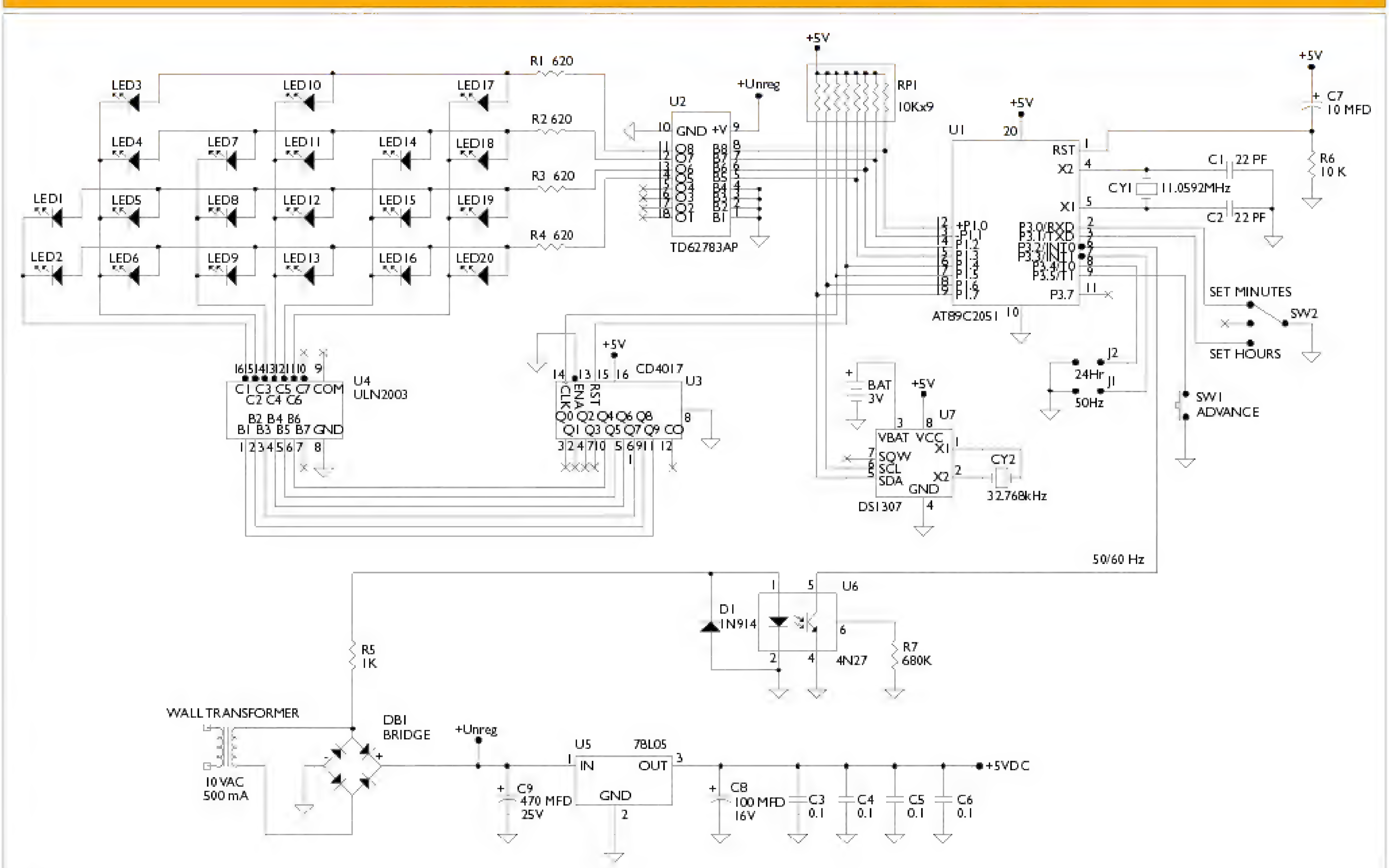
This clever clock displays time in a binary coded decimal (BCD) format — the ones and zeros of computer language. You just calculate the values of the lit LEDs in each column to derive the time. The clock runs in 12- or 24-hour mode and will operate on either 50 or 60 Hz. It also features a battery backup circuit that keeps time even when AC power is off, which eliminates the annoying hassle of re-setting the time after a power outage.

With a simple plexiglass front panel and base, the finished project is an eye-catching timepiece that is truly unique. Place it on your desk or table and watch the attention it gets.

About the Circuit

At the heart of the binary BCD clock is an Atmel AT89C2051 microcontroller programmed to handle a variety of functions, including display multiplexing, timekeeping, dot-pattern encoding, and time setting. The AT89C2051 has two kilobytes of Flash program memory, 128 bytes of RAM, 15 I/O lines, two 16-bit timers, a serial UART, an analog comparator, and a five-vector interrupt structure. It is fully compatible with the

Figure 1. The schematic diagram for the binary clock and battery backup.



Intel MCS-51 architecture and instruction set.

Even though the microcontroller is doing most of the work in the binary clock, some additional circuitry is required. Refer to the schematic diagram shown in Figure 1. The entire circuit receives power from a 10-VAC wall-mount transformer. The 10-VAC supply is rectified by the full-wave bridge DB1, filtered by capacitor C9, and regulated to five volts DC by U5.

For accuracy, the signal used by the microcontroller for its internal time-keeping functions is derived from the 50- or 60-Hz AC power line. The 10-volt AC waveform from DB1 is current limited by R5, while the negative cycles are clamped by D1. The resulting positive half wave drives the internal LED of optoisolator U6. The NPN transistor of U6 isolates and squares up the signal before it goes to the INT0 external interrupt pin of U1. No pull-up is needed on the transistor output because the INT0 input of the AT89C2051 already has an internal resistor to +five volts.

The DS1307 IC (U7), along with the crystal CY2 and the three-volt battery, form the backup timekeeping function. The DS1307 is a real-time clock chip that transfers data serially to the microcontroller through an I²C bi-directional bus. The DS1307 has a built-in power-sense circuit that detects power failures and automatically switches to the battery supply. The DS1307 could be used for the main timekeeping function of this clock, but it is not as accurate as using the 60-Hz AC power frequency. However, its timekeeping accuracy is acceptable during power outages.

Every 12 hours, the microcontroller updates the time registers inside U7 to correct for any small errors in the DS1307 time. If the AC power fails, U7 will continue to keep time by using the three-volt battery. When AC power is restored, with SW2 in the RUN position, the microcontroller will read the current time from U7 and then resume using the 60-Hz line frequency for timekeeping.

The binary clock uses 20 ultra-bright blue LEDs to show the time in the BCD format. The LEDs are connected on the PC board to form an array of four rows by six columns. The LED anodes of each row are connected together and the LED cathodes of each column are connected together creating a matrix. This configuration allows any of the 20 LEDs to be addressed through just 10 connections by using a technique called multiplexing.

Photo 1. The time here is 1:33:57.

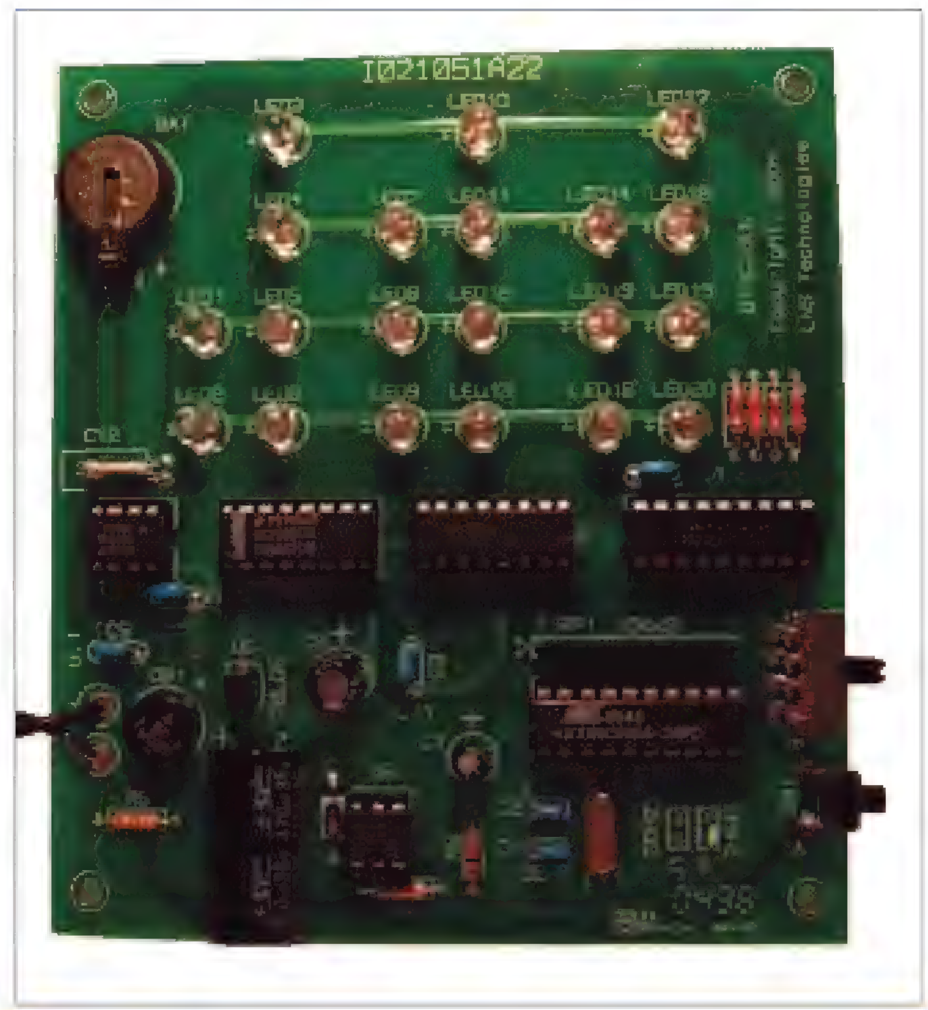


Photo 2. The layout of the LEDs.

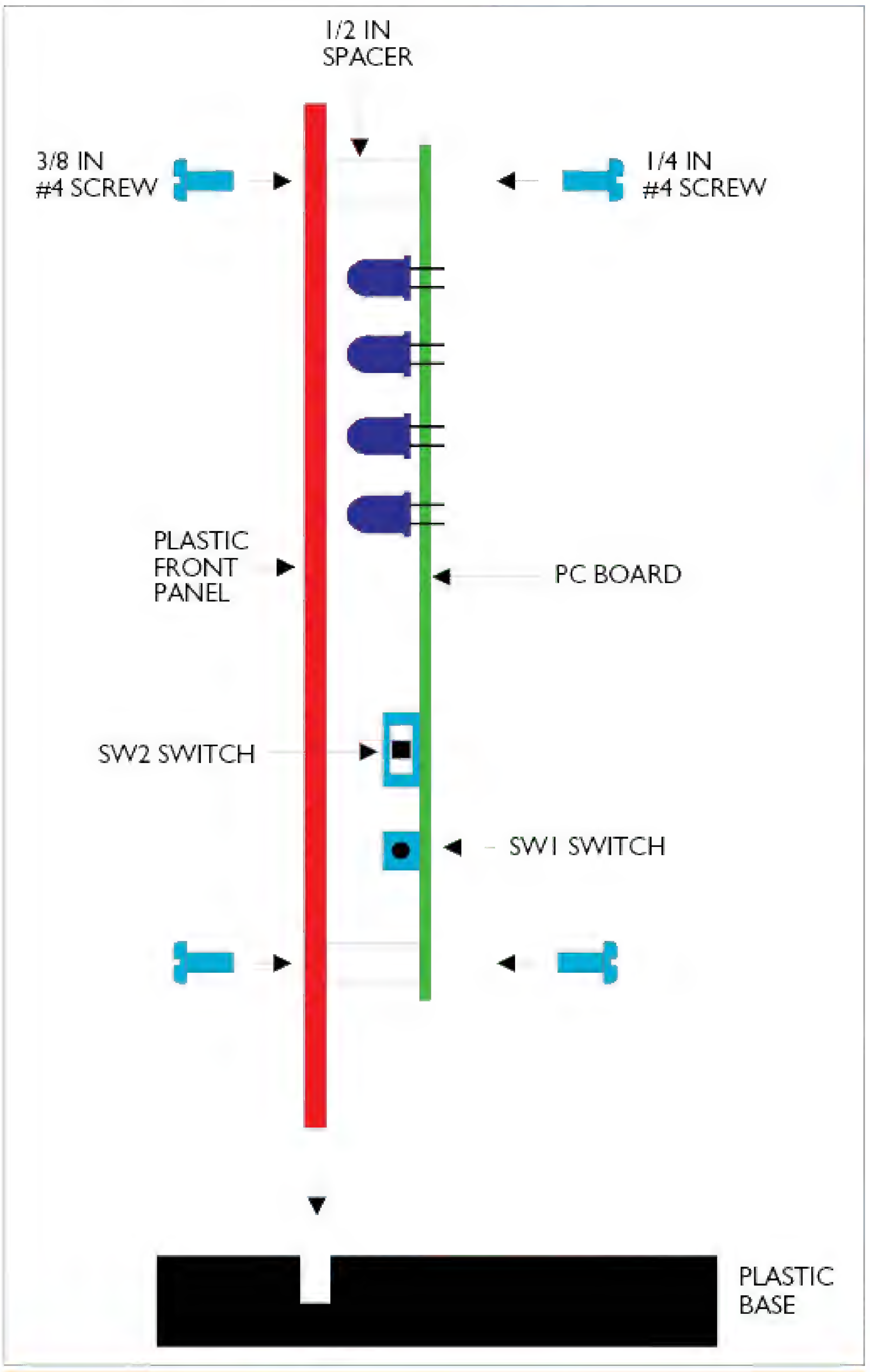


Figure 2. Assembly details.

Multiplexing

Multiplexing is a way of strobing the LEDs in the matrix to make it possible for all 20 LEDs to appear lit. In this project, the display is strobed horizontally. Refer to the schematic in Figure 1 again. The four rows are controlled by four data lines from the ATMEL microcontroller (U1). During multiplexing, it is necessary to drive the LEDs with more current than the pins of the AT89C2051 can provide, so the TD62783 driver IC (U2) is used to provide the additional LED source current capacity. A CD4017 CMOS decade counter (U3) provides a way to turn on each of the six columns in sequence. The CD4017 cannot drive the columns directly, so a ULN2003 NPN darlington array (U4) is used for LED current sinking.

Two additional output lines go from the microcontroller to U2. One is used to reset the counter so the data presented to the display rows can be synchronized with the proper column. The other is connected to the clock input of the CD4017 and is used to increment the counter. Each time the counter is incremented, the next column is enabled.

The multiplexing works as follows: First, the microcontroller resets the decade counter to enable Column 1. Then data is output to the four rows to turn on the appropriate LEDs in the first column. The LEDs in Column 1 are left on for only two milliseconds. Next, a clock pulse is generated to increment U2. As the counter increments, Column 1 is turned OFF and Column 2 is enabled. At the same time, the row data is changed to turn on the LEDs in the second column. The

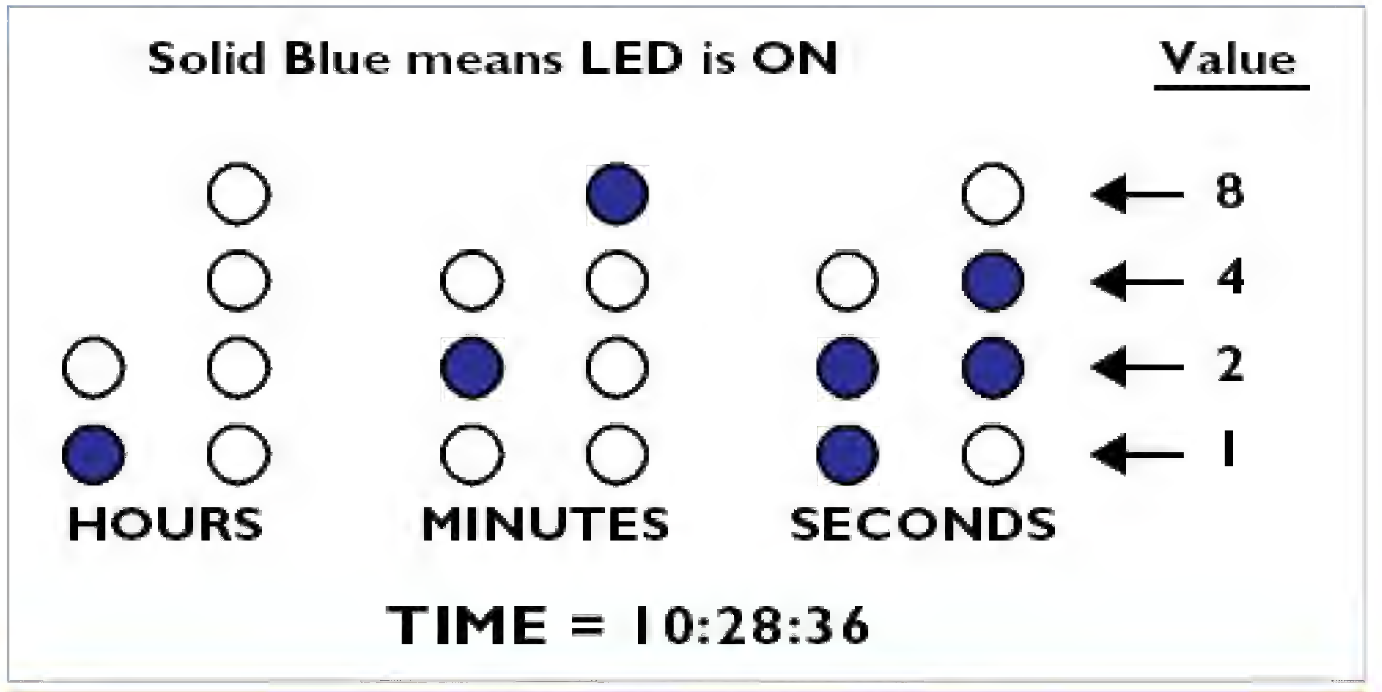


Figure 3. Reading BCD time.

How to Read BCD Time

The display has six columns of ultra-bright blue LED lights that correspond to the six digits required to display hours, minutes, and seconds. To calculate the current time from the six columns, refer to the example in Figure 3.

The first column on the left is the 10s value for hours. It has only the bottom light lit (value 1), so the value of this column is 1.

The second column from the left is the ones value for hours. No lights are lit, so the value of this column is zero.

The third column from the left is the 10s value for minutes. Only the second light from the bottom is lit (value 2), so the value of this column is two.

The fourth column from the left is the ones value for minutes. Only the fourth light from the bottom is lit (value 8), so the value of this column is eight.

The fifth column from the left is the 10s value for seconds. The bottom light is lit (value 1), as is the light above it (value 2), so the value of this column is 1 + 2 = 3.

Finally, the rightmost column is the ones value for seconds. The bottom light is off, but the light above it (value 2) is on, as is the light above that one (value 4), so the value of this column is 2 + 4 = 6.

So the time displayed is: 10 hours, 28 minutes, and 36 seconds.

sequence continues for each of the six columns before the entire process is repeated. This gives the display a 1/6th duty cycle and a refresh rate of over 80 times per second. At that speed, the human eye cannot perceive the strobing, so the display appears continuous to the observer.

Construction

The single-sided circuit board layout can be downloaded from the *Nuts & Volts* website (**www.nutsvolts.com**). Start by using solid wire for jumpers J1 through 13. Next install and solder diode D1 in place, noting its polarity. Then move on to the resistors and crystals CY1 and CY2. When mounting the diode bridge, DB1, make sure the "+" marking on the package is oriented as shown in the placement guide, which can also be downloaded from the *Nuts & Volts* website. Also observe the proper orientation on the voltage regulator U5.

Now install all the IC sockets on the board. Be sure to match the notch on each socket with the component-placement diagram, but do not insert the ICs into their sockets yet. Next, install the monolythic and ceramic capacitors C1 to C6. If you use the switches specified in the Parts List for SW1 and SW2, it can be soldered directly on the printed circuit board (PBC). Otherwise, you can run wires to the switches of your choice.

Install the three electrolytic capacitors, observing the polarities as shown in the layout diagram. Note that C9 is a radial-style capacitor, but should be mounted flush against the PC board to clear the plastic front panel.

Final Assembly

Next install and solder the battery holder to the PCB, then turn your attention to the 20 LEDs. Be sure to use the flat spot on each LED to get the proper orientation. Lastly, solder the two wires from the wall transformer to the PCB. It is important that the transformer output is nine to 10 volts AC, not DC, so the circuit has 60 Hz available for timekeeping.

Now that the soldering is complete, clean the foil side of the PCB with alcohol or flux remover, and continue by inserting all the ICs (except the microprocessor) in their sockets. Proper orientation of all ICs is important, so refer once again to the parts placement diagram for orientation details.

Before installing the microprocessor, the control software must be programmed into its EEPROM. If you have an Atmel 89C2051 programmer, you can download the

source code file BINCLOCK.ASM from the *Nuts & Volts* website or purchase a pre-programmed chip from the supplier listed in the source box. The final part to install is the CR1220 coin-cell battery in the battery holder.

If you purchased the kit listed from the supplier, it includes a plastic front panel and base to give an attractive finish to the binary clock. Figure 2 shows the assembly details for mounting the plastic panel. If you are building the project from scratch, you can be creative and choose your own method for displaying your new clock.

Optional Jumpers: J1 and J2

Before operating your clock, you may need to attach jumpers J1 and J2. J1 selects whether the clock runs on a 50-Hz or 60-Hz AC power frequency. In the United States, Canada, and Mexico, the power frequency is 60 Hz, so you should leave out J1. If you are in Europe, Australia, or anywhere else the power frequency is 50 Hz, solder a jumper wire on the PC board at the location marked J1.

J2 selects whether the clock will keep time in a 12-hour format or a 24-hour format. The 24-hour format is sometimes referred to as military time, so leaving out J2 will select the more common 12-hour format. If you want the time displayed in a 24-hour format, solder a jumper wire on the PC board at the location marked for J2.

Operation

To set the hours, move switch SW2 to the "HOURS" position shown in Figure 3, and the current hour's digits will flash in the display. Then press and hold switch SW1 to advance the hours. To set the minutes, move switch SW2 to the "MINUTES" position, and the current minute's digits will flash in the display. Now pressing SW1 will advance the minutes. When complete, put SW2 back to the "RUN" position. The time will now advance in the display. **NV**

Parts List

Resistors	**(The following resistors are 1/4 watt at five percent)**
R1-4	620-ohm resistor (blue, red, brown, gold) (qty: 4)
R5	1.0-kilohm resistor (brown, black, red, gold) (qty: 1)
R6	10-kilohm resistor (brown, black, orange, gold) (qty: 1)
R7	680-kilohm resistor (blue, grey, yellow, gold) (qty: 1)
RP1	10-kilohm x 9, SIP resistor pack (qty: 1)
Capacitors	
C1,2	22-pf, 50-volt, mono or ceramic capacitor (qty: 2)
C3-6	0.1-mfd, 50-volt, monolythic capacitor (qty: 4)
C7	10-mfd, 16-volt, electrolytic capacitor (qty: 1)
C8	470-mfd, 25-volt, electrolytic capacitor (qty: 1)
Semiconductors	
D1	1N914 (or 1N4148) signal diode
DB1	Diode bridge rectifier
U1	AT89C2051, microcontroller IC (20-DIP)
U2	Toshiba TD62783, eight-CH source driver IC (18-DIP)
U3	CD4017, CMOS decade counter IC (16-DIP)
U4	ULN2003, darlington driver array IC (16-DIP)
U5	78L05, five VDC regulator IC (TO-92)
U6	4N27 (or 4N28) optoisolator IC (6-DIP)
U7	Maxim DS1307, real-time clock (8-DIP)
LED1-20	T1-3/4 light emitting diode (qty: 20)
Miscellaneous Items	
PCB	Etched printed circuit board (BINCLOCK)
CY1	Crystal, 11.0592 MHz (ECS-110.5-S-4)
CY2	Crystal, 32.768 kHz (ECS31-8)
SW1	Momentary push button switch
SW2	SP3T slide switch (on-off-on)
BAT	CR1220 battery holder (Keystone 500)
TXFMR	10VAC, 500mA wall transformer
	CR1220, three-volt lithium battery
	20-pin IC socket (qty: 1)
	18-pin IC socket (qty: 1)
	16-pin IC socket (qty: 2)
	8-pin IC socket (qty: 1)
	6-pin IC socket (qty: 1)
	#4-40 threaded spacer, 1/2-inch long (qty: 4)
	#4-40 screw, 1/4-inch long (qty: 4)
	#4-40 screw, 3/8-inch long (qty: 4)
	Plastic front panel
	Plastic base

Source

LNS Technologies
PO Box 501
Vacaville, CA 95696-0501
1-707-448-3750
www.techkits.com

BINCLOCK-KIT: Complete kit of parts for the binary clock including etched and drilled printed circuit board, programmed microcontroller, blue LEDs, transformer, ICs, and all other components listed in the parts list $49.00

Extra parts:
AT89C2051-BCK:
Programmed microcontroller (U1) .... $12.00 ea.

BINCLOCK-PCB:
PC board for binary BCD clock .... $10.00 ea.

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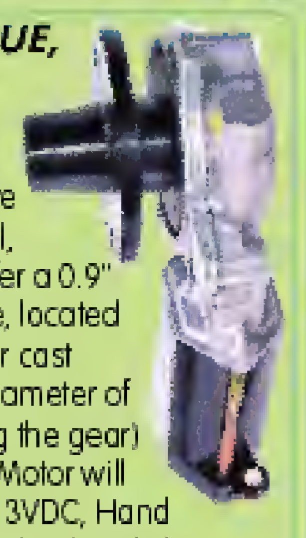
HEAVY DUTY, HIGH TORQUE, METAL CONTRUCTION.

These are brand new, very rugged, right angle drive, gearmotors originally intended for an automotive application. They are very substantial, weighing over 2 pounds each! They offer a 0.9" diameter x 0.3"H, 9 tooth steel gear drive, located centered between three 0.32" diameter cast aluminum "spider" mounting points on a diameter of 3". Overall size: 1.9"W x 7.1"L x 4"H (including the gear) with std. automotive style 2 pin connector. Motor will operate with strong torque with as little as 3VDC, Hand twisting torque at 12VDC. Current is 3.2A no load and about 6A loaded. RPM of 84/minute. Reversible. Heavy duty platic coupler included. **WINMTR248..........$20ea. 4 for $69**

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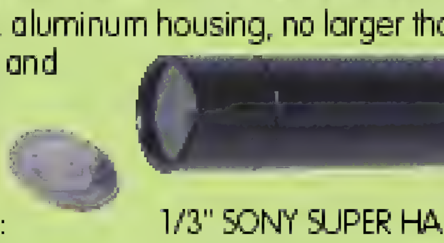

Sleek black anodized, aluminum housing, no larger than a dime! O-Ring sealed and weatherproof. (not for underwater use) Adj. tilt / swivel mounting bracket. Specifications: 1/3" SONY SUPER HAD CCD, 400 Lines Resolution, SUPER 0.01 Lux sensitivity, AGC, Auto Shutter, (1/60 to 1/100,000) Power from regulated 12VDC @100mA, Super 3.6mm, 90° FOV real glass lens, NTSC video. Extra IR SENSITIVE. Size: 0.735"D X 2.15"L 50mm, 36" cable with BNC video & DC barrel jack. Weight: 65g Superior quality at an affordable price. Limited qty. **GM-L250........$59ea.**
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NTSC or PAL, 1 Camera Input with Loop Through, Resolution: 720 x 484 (NTSC) ; 720 x 576 (PAL), Built-In Compact Flash Card Slot, Alarm Input & Output, Audio: 2 In; 2 Out, Video Loss Detection, RS-232, Event Log, 80GB, 3.5" IDE Hot Swappable Drive, Timer or Event Recording, Record & Playback rates: 0.2~60 FPS (NTSC); 0.1~50 FPS (PAL). Playback Search: By Date/Time, Event, or Segment. On-Screen Setupy, Menu Driven User Interface, Front Panel Keypad, Real Time Clock, Watch Dog Timer. Power: AC 100-240V + 10%, Max AC 1.5 Amp, 39 W max, Operating Temp.0°C ~ +40°C, Dimensions: 12.6"L x 8.5"W x 3.9"H. Weight: 11 pounds. **GM-100H.....$399ea.**

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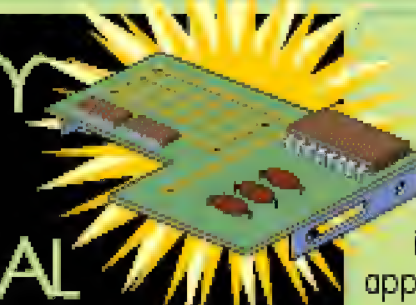

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V (in)	I (nl)	RPM
3	2.7A	16
6	3.1A	39
9	3.3A	63
12	3.5A	88

Motor will operates with wrist twisting torque. As little as 3VDC lights it up, nominal is 12VDC. Draws 4.5 Amps under load. All metal. It is reversible.
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Sleek black anodized, BRASS housing. O-ring sealed and WATERPROOF (down to 60 feet). Adjustable mount included. Specifications: 1/4" CCD, 350 lines resolution, 0.5 Lux sensitivity, AGC, Auto shutter. Power: 12VDC @ 120mA, 4mm 78 deg FOV lens. A real glass lens. NTSC video out. Superior construction. Ultra small. Size: 1.25"d x 2" L. 60 foot, Kevlar reinforced cable. Perfect for fishing or as a remote area inspection camera. Great for weatherproof outdoor use as well. Now with twelve, super bright, white light LED's.
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V (in)	I (nl)	RPM	Amps Loaded
3	900mA	26	
6	1.0A	57	5A
9	1.1A	89	
12	1.2A	117	

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This simple device solves the problem of time stamping & identifying any video. Camera ID up to 20 characters, ID & Time on/off, ID at top center of screen & time on the bottom. Format: YR/MO/DAY and HR/MIN/SEC/ 24hour Std. RCA video in & out. 9VDC, AC adpter incl. Three button operation. Rugged case. Size: 3.5"L x 2.6"W x 1.25" H. **SPECIAL..........$55ea.**

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Build a Geiger Counter: Part 2

Adding Enhancements

In the March 2005 issue, we completed a fully functional basic Geiger counter. This month, we have a few cool enhancements to add on.

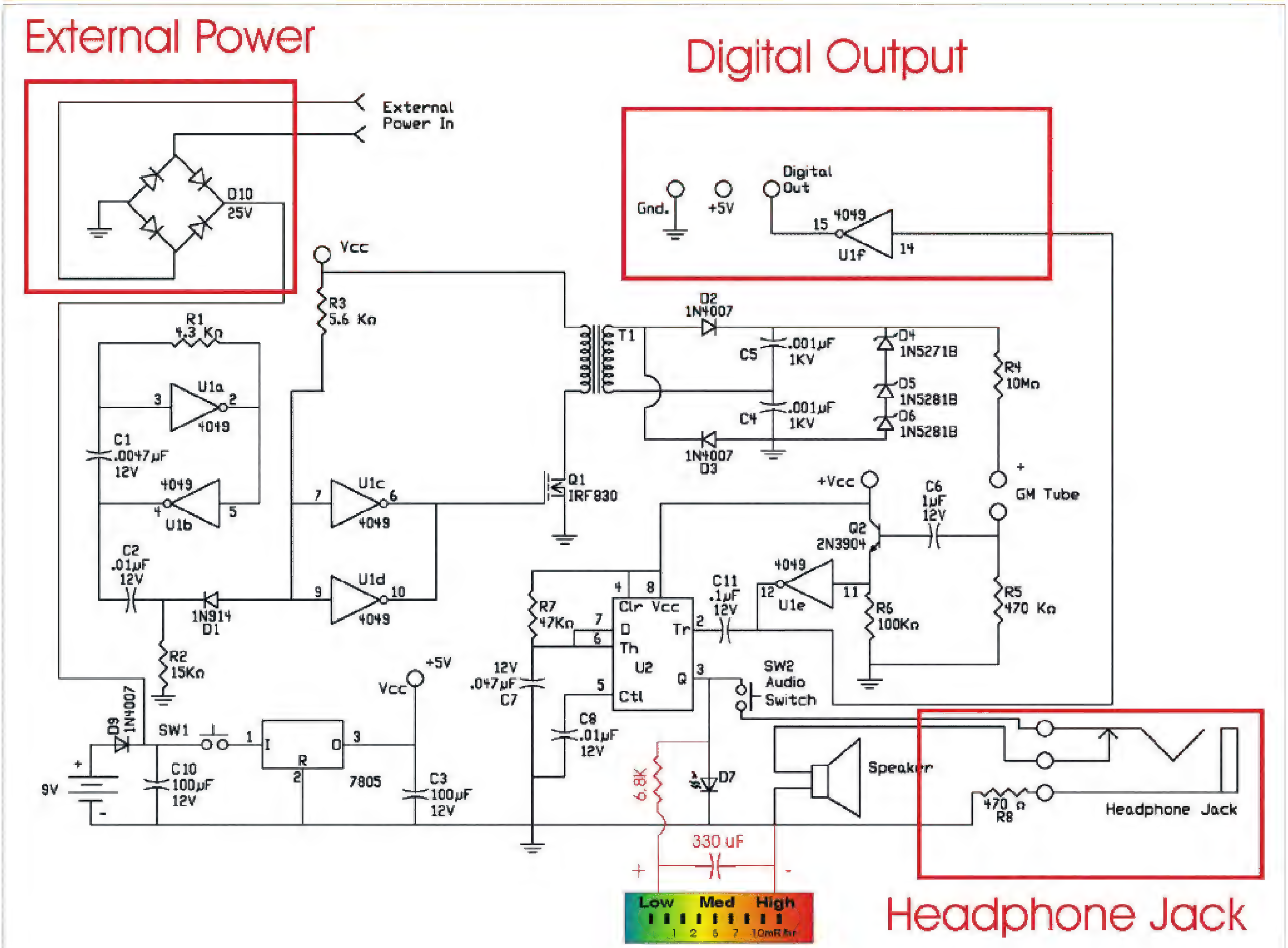
Revised Schematic

Note the revised schematic shown in Figure 1. The basic Geiger counter circuit is identical to the previous circuit, except for the necessary components to complete the enhancements. The three optional add-ons include: an external power input, a headphone jack, and a digital output. The enhancements are highlighted in red boxes.

Available Add-ons

External Power — The external power is designed to allow a wide range of wall transformers to power the Geiger counter. Wall transformers that can supply a minimum of 75 mA with voltages that range from 7-12 VAC or 7-12 VDC will work. The bridge rectifier is rated at 25 V, one amp. Pretty much any bridge rectifier with specifications close to these (or better) will work when placed

Figure 1. Revised schematic showing the enhancements in red boxes.



inside the circuit. The positive output lead of the bridge rectifier is placed after the D9 diode. The D9 diode protects the battery when using external power.

Headphone Jack — Aside from its obvious use for a headphone, this jack may also be used as a temporary output for an analog meter. The headphone jack is a 3.5 mm two-conductor jack with an SPST switch. The switch automatically disconnects the speaker when the headphone or analog meter is plugged in.

Digital Output — The digital output jack provides a +5V TTL logic pulse every time a radioactive particle is detected. The digital output uses an unused gate off the 4049, as shown in the schematic. We will build a small interface between this output and a Windows PC. This will allow you to use one of the free Geiger counter graphing programs.

For those who purchased the PC board for this project, the enhancements may be added by wiring in the three jacks, as shown in Figure 2.

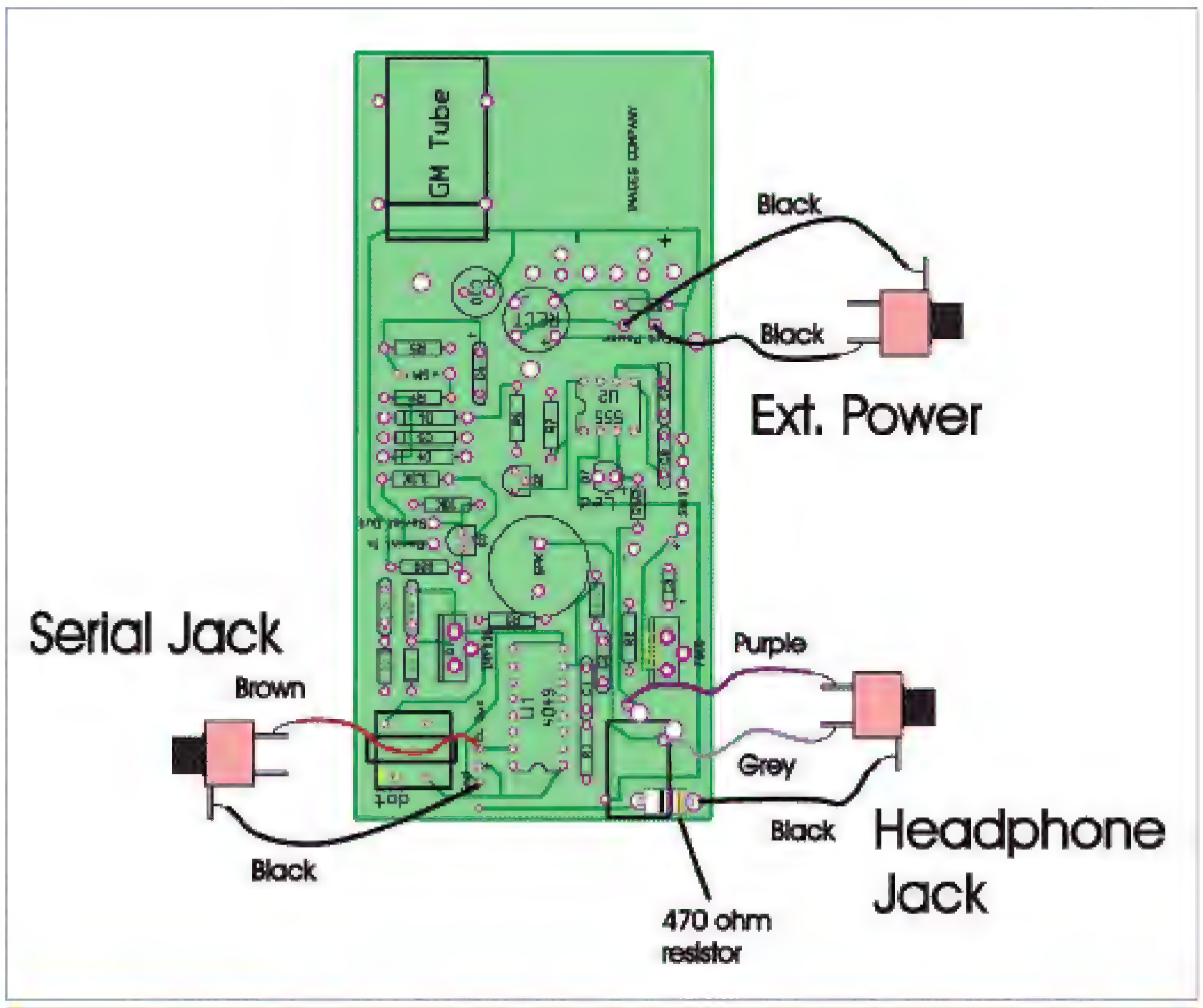


Figure 2. Connecting the three 3.5 mm jacks to the PC board.

Analog Meter

The analog meter in Figure 3 will provide approximate radiation levels to 10 mR/hr. The analog meter may be set up in one of two ways. It may be permanently wired into the circuit or used temporarily by plugging it into the headphone jack.

To connect the meter permanently to the Geiger counter circuit, wire the 6.8 K 1/4-watt resistor, 330 uF capacitor, and meter across the LED, as shown in the schematic.

A stand-alone analog meter that plugs into the headphone jack is shown in Figures 4 and 5. Figure 4 also shows that by adding a single 6.8 K resistor and switch, you can double the range of the analog meter to 20 mR/hr. When SW1 is closed, it short-circuits resistor R2. This provides a reading range of 0-10 mR/hr. When SW1 is open, resistor R2 is in series with R1 and the range doubles to approximately 0-20 mR/hr.

Windows Geiger Counter Radiation Monitor Program

Figure 6 is a screen image of the Windows Geiger counter radiation program. This program is free and is available for download at: **www.imagesco.com/geiger/index.html**

You may download the WIN98 or WINXP version of the program, depending upon your computer's operating system.

The program gathers information it receives on one of its COM ports and displays the information on the PC screen. The information graphed is the Counts Per Second (CPS) from the Geiger counter. The CPS scale is shown on the left side and the equivalent radiation level in mR/hr is shown on the right side. The program automatically scales, depending upon the CPS read. The graph continuously scrolls to the right with updated information. The graphs created with this program may be saved on disk and loaded for review later.

The amount of data that may be saved is limited by the memory in your system or space available on your hard drive, but it's safe to say you most likely could continue to graph for weeks.

Figure 3. Closeup of the analog radiation edge meter.

Figure 4. Schematic of the analog meter (headphone jack plug-in).

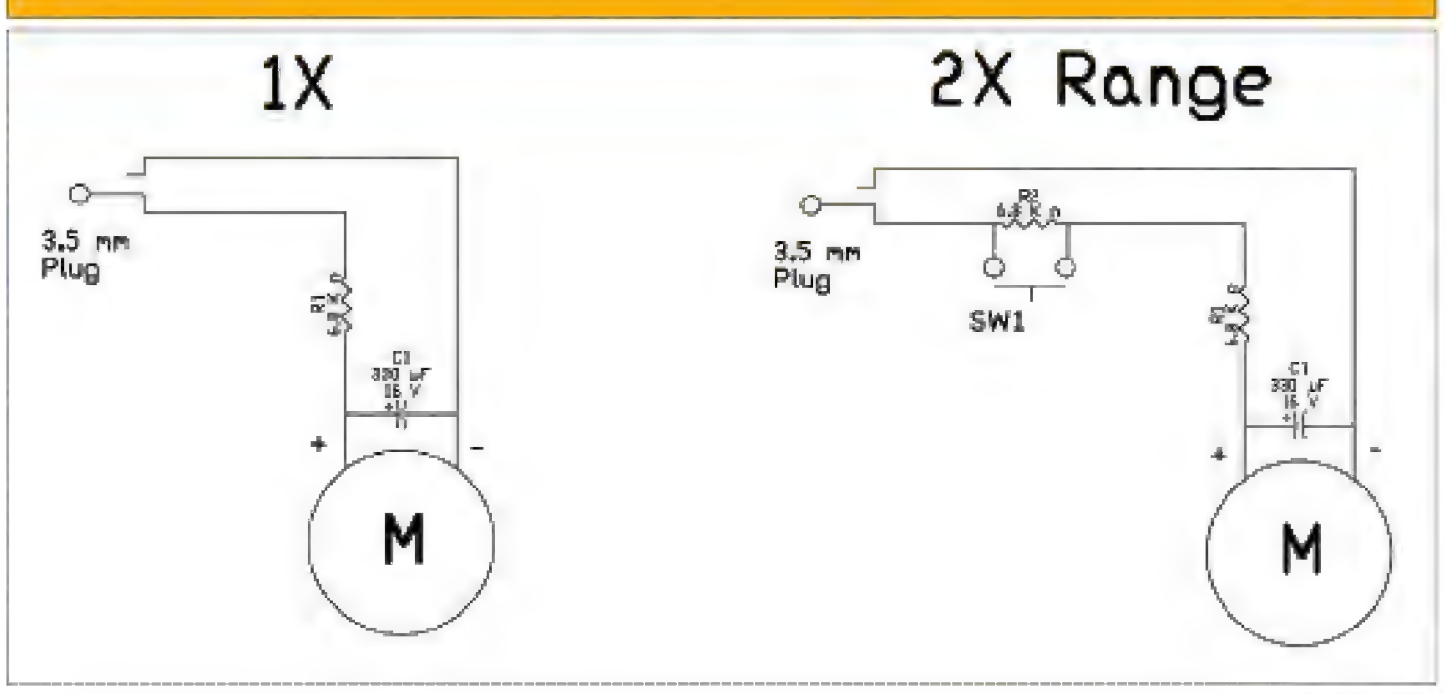


Figure 5. Photo of Figure 4 ready for mounting inside an enclosure.

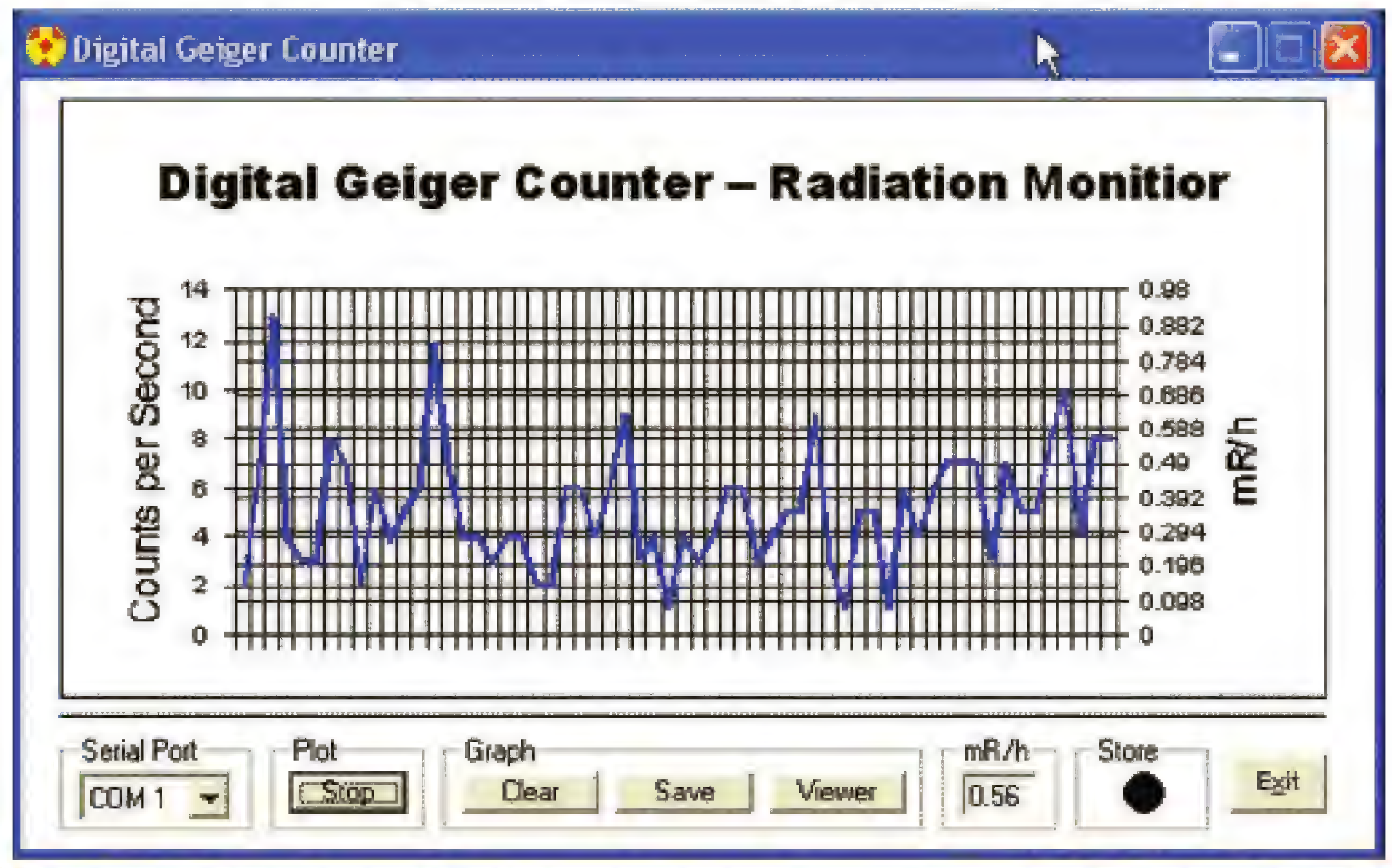


Figure 6. Screen of PC radiation monitor Windows program.

PC Interface

The PC interface performs two functions. First, it counts the TTL digital pulses from the Geiger counter in one-second intervals and then sends that information out in a standard 9600 baud RS-232 format. The schematic for the interface is shown in Figure 7. A nine-volt transistor battery powers the PC interface. The voltage is regulated down to five volts for the PIC microcontroller.

Notice, however, that the full nine volts from the battery is provided to the top of R2. This section makes up the RS-232 connection to the PC. The +9V from the circuit is close enough to the expected +12V of the RS-232 connection on the PC to make a reliable serial connection. The female DB-9 connector on the interface incorporates a NULL modem to facilitate communication with the PC. A circuit prototype is shown in Figure 8.

PIC Program

The following PIC program was written using the PICBasic Pro Compiler. For any readers who prefer a preprogrammed 16F84-20 MHz chip, one is available from the source in the Parts List.

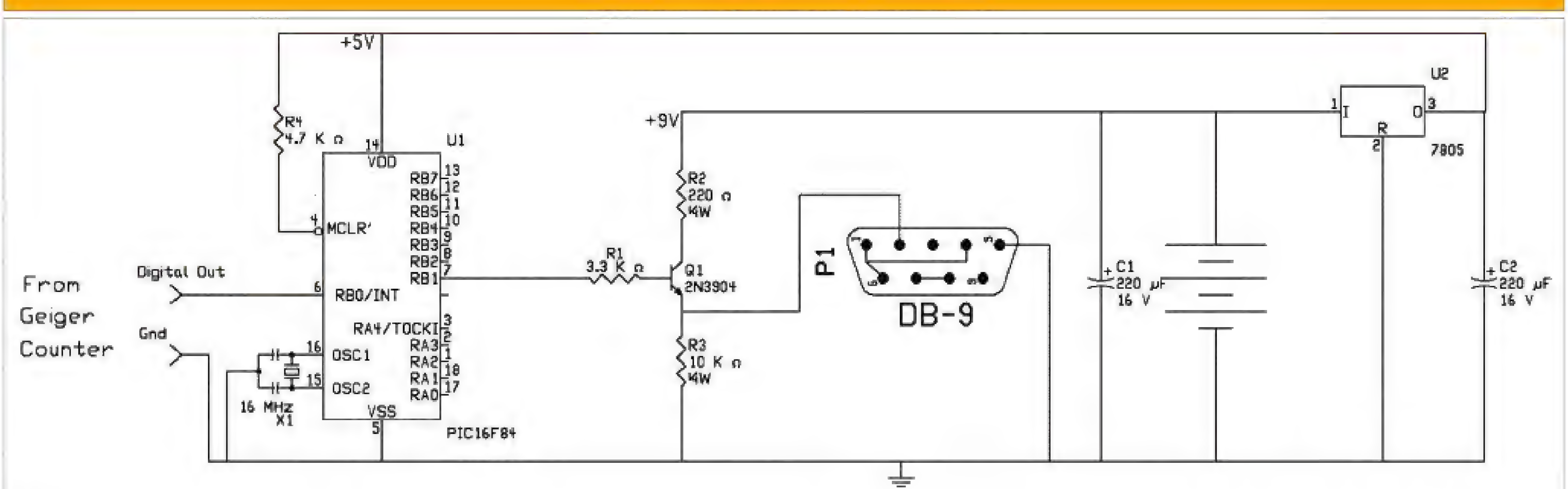
```
'REM John Iovine 11/04
'Read Digital Output & send RS-232 info to PC
'Use 16F84-20MHZ microcontroller & 16 MHz Xtal

DEFINE OSC 16                          'Use 16 MHZ Xtal
'Declare word variables
 w1 VAR WORD

Start:                                 'Main Program
Count PORTB.0, 1000, w1                'Count pulses every
                                       'second
SerOut 1,6, [w1.byte0, w1.byte1]       'Send Information to PC
GoTo Start                             'Do it again & again &
                                       'again & ...
End
```

Windows Program Operation

Unzip the program file you have downloaded from the website into its own directory. Run the Setup.exe program to install the software onto your computer. Once installed, run the Geiger counter program. Connect the PC interface to one of the PC's serial (COM) ports. Select the COM port the interface is connected to in the Windows program. The program will only list the COM ports it finds on your computer. Typically, PCs have more than one COM port.

Connect the digital out of the PC to the interface and

Figure 7. Schematic of PC interface.



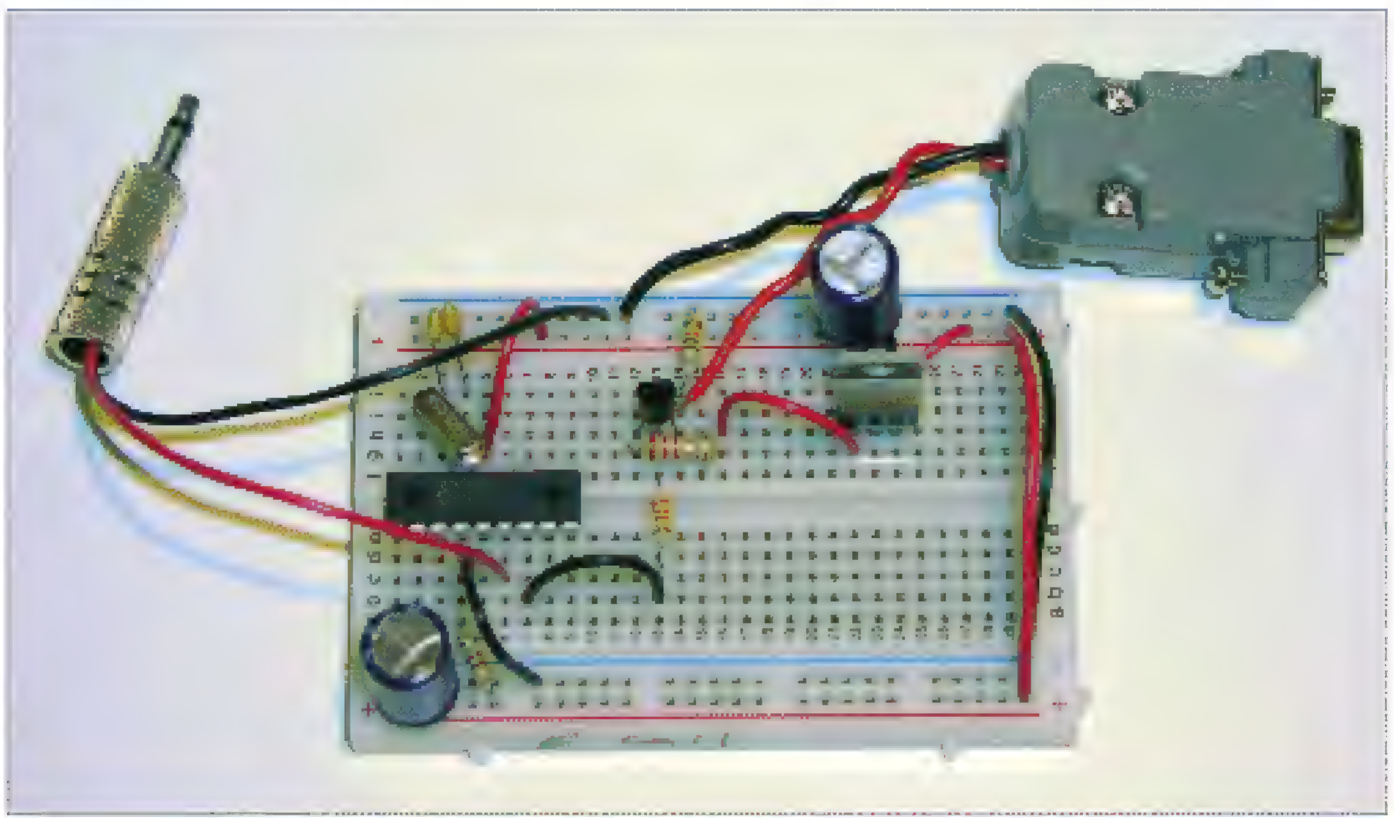


Figure 8. The prototyped PC interface.

turn the Geiger counter on. If you have any radioactive material bring it close to the GM tube.

Hit the "Start" button on the program to begin plotting.

Radiation Shielding — Detecting Different Radiation

I have been asked on a few occasions about proportional Geiger counters; geiger counters that can differentiate between gamma, beta, and alpha radiation. While these GM tubes are available, they are more expensive and require a variable HV power supply. The tube's voltage is varied to different preset voltages to detect different types of radiation.

A simpler method is to provide radiation shielding to your GM tube. To block alpha radiation, cover the front mica window of the GM tube with a few sheets of paper. This will effectively block the alpha radiation and allow just beta and gamma radiation through the tube to be detected.

To block alpha and beta radiation; cover the tube with 1/8" thick aluminum. This will effectively block the alpha and beta radiation and allow just the gamma radiation through the tube to be detected.

To block gamma radiation, depending upon the energy of the radiation, you may need several inches of lead.

Granted, this simple shielding doesn't provide the versatility and usefulness of a proportional counter but, in some cases, you will find it helpful.

Going Further — Data Logger

The PC interface circuit can be a springboard to more Geiger counter projects, for instance, the addition of an LCD display to make a digital Geiger counter or perhaps a graphing LCD module. Perhaps one could add an EEPROM memory and create a portable data logger. If you would like to see more enhancements for this Geiger counter, contact me via *Nuts & Volts* at editorfs@nutsvolts.com and let me know.

Housing

Figure 9 shows the finished PC board. All that's left to complete this project is a housing. You may use any enclosure large enough to contain the components. However, I recommend using a plastic, non-conductive housing. This will help keep you safe from the +500 VDC GM tube supply and prevent grounding out the supply to the case and causing a short circuit. **NV**

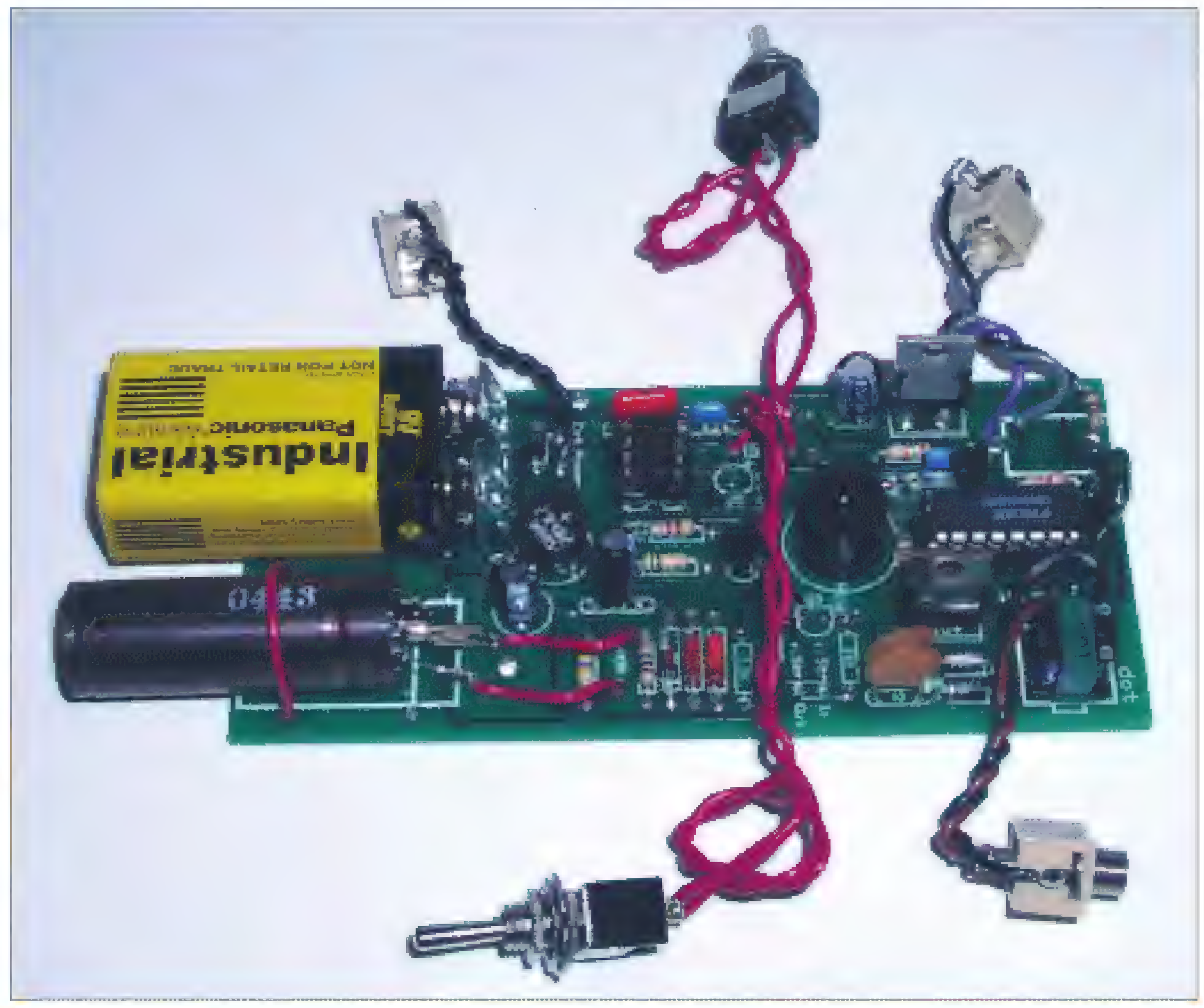


Figure 9. Finished PC board ready for mounting inside an enclosure.

Parts List

Geiger Counter Enhancements	
(3) 3.5 mm jacks with SPST switch	$ 0.50 each
470 ohm 1/4 watt resistor	$ 0.03
Bridge rectifier 100PIV 1.5 amps	$ 0.25
Analog meter	$11.95
330 uf 16V capacitor	$ 0.35
6.8K ohm 1/4 watt resistor	$ 0.03
PC Interface	
16F84-20 MHz microcontroller (pre-programmed)	$ 9.95
16 MHz Xtal	$ 1.50
(2) 22 pf capacitors	$ 0.10
(2) 220 uf 16-volt capacitors	$ 0.25
2N3904 NPN transistor	$ 0.20
220 ohm 1/4 watt resistor	$ 0.03
10K ohm 1/4 watt resistor	$ 0.03
3.3K ohm 1/4 watt resistor	$ 0.03
4.7K ohm 1/4 watt resistor	$ 0.03
7805 voltage regulator	$ 0.42
DB-9 female connector (solder cups)	$ 0.75
Plastic hood for DB-9 connector	$ 0.75

Parts Available from:
Images SI, Inc.
109 Woods of Arden Road
Staten Island NY 10312
718.966.3694
www.imagesco.com

SUPERCOMPUTING
IN THE NEW MILLENNIUM

BY
DAVID GEER

This is Not Your Father's Supercomputer

Do you think your computer is fast? It's a top-of-the-line system with all of the optional bells and whistles, bought at the best store in town, no expense spared, so it should be fast, indeed. However, it can't be classified as a supercomputer the same way Superman can't be classified as a mere mortal man. In the vast realm of the consumer computer world, the power and speed of your multi-GHz-powered processor is a drop in the bucket to the juggernaut-like power it takes to be labeled a supercomputer, especially with the geometric advancements of technology in the 21st Century. Imagine how laughable the power of these computers will be to us in a few decades, especially considering how far computers have come since 1981 when Bill Gates — believe it or not — was quoted as saying, "640K ought to be enough for anybody."

BlueGene/L Beta

The term "supercomputer" sounds like old technological jargon to us now, but by definition, they are always new. A supercomputer is any computer among the fastest on the planet at any given time, and the world's fastest supercomputer today — the fastest computer period — is the BlueGene/L Beta (**www.research.ibm.com/bluegene**), part of a project from the Department of Energy and IBM. Housed in Rochester, NY, the BlueGene/L clocks a whopping 72 teraflops (floating-point operations per second, also known as TFlops). A single TFlop is a billion floating-point operations per second, and a scientific example of a floating-point operation is the multiplication of two numbers that both contain decimal points.

A good comparison of the computational power of IBM's supercomputing behemoth goes something like this: Assuming that all the PCs are high-end models with 3.0-GHz, Pentium 4 processors operating in a typical mode, it would take 23,573 of them to see the same sustained performance as the BlueGene/L.

"The BlueGene/L demonstrates the leadership of DOE and IBM in terms of high-end computing," says Russ Miller, director of the Center for Computational Research at SUNY-Buffalo, one of the leading academic supercomputing sites in the country."The current system consists of over 32,000 relatively slow PowerPC processors and is packaged in only 16 racks, while consuming relatively little power. One of the most impressive features of the system is its ability to handle data movement into, out of, and within the system."

IBM's primary BlueGene/L partner, the Department of Energy's National Nuclear Security Agency, will have a 360-teraflop Blue Gene/L supercomputer up and running later this year. This will constitute an increase of more than 500 percent over the current BlueGene/L.

Columbia SGI Altix

Crossing the finish line as the second fastest computer in the world is the Columbia SGI Altix 1.5-GHz Voltaire Infiniband from NASA and SGI (Silicon Graphics, Inc.). Comprised of 10,160 Intel Itanium 2 processors, the system has a peak speed of 60 TFlops and a maximum sustainable speed of 51 TFlops.

The Linux-based system was assembled at NASA's Ames Research Center at Moffett Field, CA, 120 days from project inception. Named in honor of the lost Space Shuttle and crew, the Columbia aids NASA's space initiatives.

As Columbia continues to accelerate in breakthroughs in engineering and science, its computational capacity will soon be available to the national science and engineering community.

Earth Simulator

Coming in at third place is the Earth Simulator (**www.es.jamstec.go.jp**), which clocks a whopping 35 TFlops at a maximum sustained speed.

"The Earth Simulator is a huge non-commodity system in a building of several floors," says Professor Russ Miller, Director of the Center for Computational Research, University of Buffalo. It was the fastest supercomputer from June 2002 to June 2004, only to be supplanted by IBM's BlueGene/L Beta in November. (My, how time and TFlops fly!)

Mainstreaming the Egghead Computer

"Over the past decade," says Miller, "supercomputing has been taking advantage of the commodity market, includ-

A SUPERCOMPUTER IS ANY COMPUTER AMONG THE FASTEST ON THE PLANET AT ANY GIVEN TIME.

THE SCIENCE APPLIANCE, BUILT BY LINUX NETWORX, HARNESSES THE POWER OF 2,050 INTEL PROCESSORS.

PLAYSTATION 2 CLUSTER. PHOTO COURTESY OF THE NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS.

ing processors, memory, storage, and connectivity between processors. However, significant gains in the highest-level supercomputers continue to come from new research and development efforts from very smart scientists and engineers."

Because so many fast and cheap computers have been hitting the market, high-performance computers are now readily available to more institutions in order to support computational science and engineering in the data-driven society that we live in. Such systems take advantage of Moore's Law — the discovery of Intel co-founder Gordon Moore — which says that processors get twice as fast every 18 months for the same price.

But What Do They Do for You and Me?

Supercomputers bring us the latest Hollywood films, animations, and advertisements. "A lot of the morphing you see — the interesting features of motion pictures — are done with supercomputers," says Miller. The oil industry uses supercomputers in modeling. It models what is underground in order to find new oil deposits. This keeps prices down on oil operations and limits unnecessary diggings. "Supercomputers have become critical to life sciences, physical sciences, engineering, media, and virtual reality," Miller says.

Supercomputers determine the positioning of atoms in molecules. They model how new drugs interact with people based on research. "Researchers are shaving years off the development cycle," adds Miller. The process "weeds out the scrubs" much faster among drugs being tested. This helps find drugs that will pass muster and actually get to market more quickly. Many prescriptions are coming to market seven to 10 years ahead of schedule because of supercomputers.

Weather forecasts, space experimentation, and many other services and industries are affected by supercomputing. Supercomputing brought us overlays and graphics in TV sportscasting. "If you look at the 10-yard marker that magically shows up across the screen, that used to take supercomputing capabilities — and now, with slightly smarter algorithms and pretty good machines, that's actually being done on high-end workstations," says Miller.

The particular benefit to commercial industry in using cluster supercomputers is going to be quicker development of products and services, as new products and services will come to market faster. "That was the whole motivation for the industry adopting supercomputing some 22 years ago. Now with the clusters, the real price performance advantages improve at least at a factor of 10, if not more, over traditional mainframes," says Eric Pitcher, VP of Product Marketing, Linux Networx.

According to Pitcher, the Linux Networx system at Livermore is 8.6 times more powerful than Deep Blue, the IBM computer that beat world chess champion Garry Kasparov in 1997. The Linux Networx system can hold in its memory the entire Library of Congress nearly five times over, and it can assemble the human genome in 18 days, compared to the 150 days it took the Compaq Alpha Cluster Celera that was actually used. The Linux Networx system is 5.6 times more powerful than the Sun Enterprise render farm used by Pixar to create the movie *Monsters, Inc.* By comparison, today, IBM's BlueGene/L Beta can store the Library of Congress nearly 50 times over and assemble the human genome in about two days.

Supercomputing, Grid Computing, and Where the Two Meet

Clusters using like nodes can be interconnected together

THE 500 FASTEST SUPERCOMPUTERS IN THE WORLD

There is no official cutoff point for speeds at which computers don't qualify as supercomputers. There is, however, a list of the fastest computers in the world, updated every six months. "The bible of supercomputing speed is the Top 500 list (**www.top500.org**)," says Russ Miller, director of the Center for Computational Research at SUNY-Buffalo.

"The cutoff in power is continually increasing with the publication of the list every six months," says Eric Pitcher, VP of Product Marketing, Linux Networx. As supercomputers rapidly increase in power, the minimum speed required to make the list increases.

"The new Top 500 list at **www.top500.org** which came out November 2004, has a total of 296 clusters within the top 500," adds Pitcher. This is an increase of 350 percent over those that made the grade for the previous list.

Because cluster supercomputers are proving to be reliable, cheaper, and faster than traditional supercomputers, IT managers' adoption of these machines has accelerated. This will certainly fuel the desire to get on the list of the very best.

at any location to form powerful supercomputers. Grid computing takes computers — which may or may not be in the same location and are not necessarily alike — and links them together so that they can solve large problems as a team.

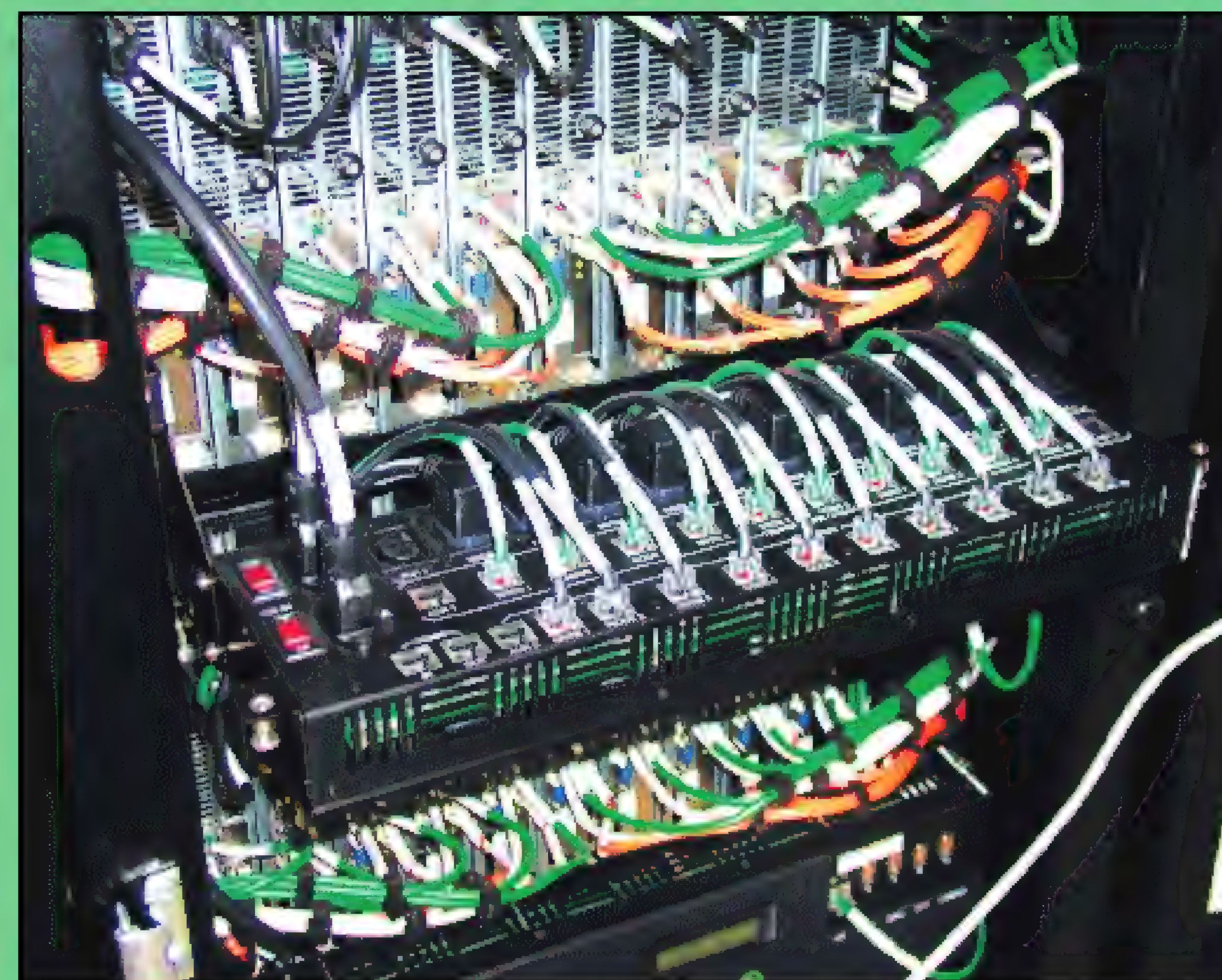
"The National Science Foundation (NSF) has a program out called the TeraGrid that's connecting nine sites around the country: The Pittsburgh Supercomputing Center, The National Center for Supercomputing Applications (NCSA), Argonne National Labs, San Diego Supercomputing Center, Cal Tech, Oak Ridge National Labs, University of Texas at Austin, Purdue, and Indiana University," says Miller. The nine sites are joined through a 40-gigabit (Gbit) backbone, with a minimum 30 Gbits to each site. The NSF, says Miller, "is connecting these sites because scientists and engineers want to be able to look at a comprehensive grid of machines and instruments."

TeraGrid entered its full-production phase in October 2004, and researchers interested in TeraGrid access should check out the Getting Started guide at **www.teragrid.org**

How to Start Your Own Cluster Supercomputer

According to Miller, with today's state-of-the-art, off-the-shelf clusters, you can build your own single TFlop supercomputer for well under $200,000.00. That's assuming you have the air-conditioning and the electricity to keep it cool and to run it. You'll need clusters, which means racks and racks of servers, and you'll need a commodity interconnection network from companies like Myricom (**www.myricom.com**) or Quadrics (**www.quadrics.com**) and some management software.

Short on cash? We're about to introduce you to a commodity supercomputer that comes in under $50,000.00.



THE ICEBOX MANAGEMENT APPLIANCE FROM LINUX NETWORX MONITORS CLUSTER HEALTH.

The NCSA's PlayStation 2 Cluster Supercomputer

About two years ago, the NCSA strung together 70 PlayStation 2 devices to form a small supercomputer. "That's taking commodity processing to the next step. They looked at these very low-cost games that all of our kids have up in their rooms and said, 'Look, there's some really fast processors here.' In fact, the graphics engines in those machines are really fast," says Miller.

With Sony's Linux Kit (Linux version 2.2.1, no longer available in North America), the NCSA clustered the

games together with some interconnection networking, and they ended up with a comparatively inexpensive, yet very powerful, computer system. According to Craig P. Steffen, NCSA Senior Research Scientist, the PlayStation 2 supercomputer is a cluster computer that employs the same techniques used to make NCSA's large production clusters such as the Titan, the Platinum, and the Mercury.

To learn more about the PlayStation 2 supercomputer, check out the project site at: **http://arrakis.ncsa.uiuc.edu/ps2** See: **http://arrakis.ncsa.uiuc.edu/ps2/other_projects.php** for updates on other PlayStation 2 supercomputer and grid computing efforts.

Supercomputing Rocks!

According to Russ Miller, the NSF, through the Partnership for Advanced Computational Infrastructure (PACI), has put out a software package called ROCKS. For about $50.00 to $70.00, a home user can buy a small Ethernet switch and hook up four home computers via Ethernet. They can install the ROCKS software and harness the power of those four machines to solve an individual problem. Check out **www.paci.org** for the NSF's supercomputing activities, educational tools, and software.

Other Options to Tinker With

"We also deliver small systems, whether it be eight nodes or 16 nodes, each node having two processors," says Pitcher. These can be delivered to smaller plants like engineering shops and the newer life science companies. "Supercomputers are not just the great big machines that are delivered to the national labs anymore, but they are quite pervasive throughout our economy," he adds.

Linux Networx also has a solutions center where customers can come in and "kick the tires," so to speak. They can bring in their own software, install it, and configure it to solve problems. It's a great place to get your hands on some supercomputing power. "The solutions center is located at Linux Networx's headquarters in a suburb of Salt Lake City, UT, called Bluffdale," says Pitcher. Checking out the center is just a matter of contacting your local Linux Networx representative.

The Future of Supercomputing

"Many industry observers say Moore's Law will continue for at least the next eight years without any earth shattering breakthroughs in new technology," says Pitcher. Processor performance and interconnect performance will continue to expand, while the amount of power we can pack into the same sized processor will continue to grow.

Conclusion

Because we will always need to solve the next larger set of problems — greater than the ones before — we will always need to build more powerful supercomputers than we have. In the foreseeable future, there will be jobs only a supercomputer is big enough, strong enough, and fast enough to take on.

"It's like comparing ball players or boxers from different generations, right? At any point in time, there is always the next set of larger and more complex problems than you could typically solve using a set of workstations in a laboratory," says Professor Miller. **NV**

WILL THE REAL SUPERCOMPUTER PLEASE STAND UP?

Though not on the Top 500 list, Google's server farm is estimated to constitute the world's fastest supercomputer.

Google's worldwide Linux server farms respond to search requests at the fastest available compute rates. Based on Google's IPO S-1 form (April 2004), an executive in the Internet division of a large financial firm estimated the worldwide server farm's constructs and capacity: The Google "supercomputer" is comprised of over 700 server racks, 63,000 computers, 126,000 processors, 253,000 GHz of processing power, 126,000 gigabytes of RAM, and more than 5,000 terabytes of hard drive space.

According to this estimate, the Google server farm constitutes the most powerful supercomputer in the world, performing at least three times as many calculations per second as the Earth Simulator, and about 50 percent more calculations per second than IBM's BlueGene/L Beta, which is at the top of the Top 500 list!

RESOURCES

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PIC VIDEO
PART 2: Video Text Overlay With a PIC Microprocessor

BY ROBERT LANG

Last month, I described the hardware necessary to build a unit that will allow one to do video text overlay with a PIC microprocessor. We will conclude this month with the software programming of the microprocessor, testing the system, and experimenting with the techniques of subliminal messaging.

Main Program

You may wish to download a copy of the software, PICVIDEO.ASM, from Reference 1 and follow along with it as I explain. A complete datasheet on the 16F877 microprocessor can be found in Reference 2. The main program performs several functions by calling up subroutines. It initializes the serial port by calling INITIALIZE_SERIAL_PORT and then initializes the memory that contains the text to be displayed (0x35 to 0x41) to "PICVIDEO V6.0" by calling INIT_VIDEOTEXT. Next, the main program calls UPDATE_VIDEOMEMORY to build an image in video memory (0xA0 to 0xFA) of the scan lines to be displayed. Finally, the main program enables interrupts on RB0 (for scan-line interrupts), on RC7 (for serial character received interrupts), and on TIMER1 (for display delay interrupts).

Following the above initialization, the program goes into an infinite loop, where it checks to see if video text memory has changed by checking the DISPLAY_UPDATE_REQUIRED bit. If the bit is set, then UPDATE_VIDEOMEMORY is executed in order to update the video memory containing the scan line information to be consistent with the video text memory.

The process for loading the video memory is shown in Figure 1. Because tables on the 16F877 are limited to 256 bytes, the dot patterns have to be stored in two tables called ALPHA_DATA and NUMERIC_DATA, as shown in Table 1 of Part 1 (April 2005 *Nuts & Volts*). Each character's bit pattern occupies eight consecutive bytes. Custom characters can be easily created by changing the bit patterns in ALPHA_DATA or NUMERIC_DATA contained in the file VDATA.INC. I created a custom "degree F" character to replace the standard "@" in ASCII.

Once a character is identified, its dot pattern is looked up in the ALPHA_DATA or NUMERIC_DATA tables. The video memory is loaded with the first line of dot data for the 13 characters in display, then with the second line of dot data for the 13 characters in display, then with the third line of dot data for the 13 characters in display, and so forth, until all seven lines of non-zero dot data are loaded sequentially into the video memory. Thirteen characters take seven lines x 13 characters, or 91 bytes, of video memory to store the dot patterns. The dot patterns need to be stored rather than generated as needed to save microprocessor time during the horizontal scan.

Interrupt

There are three events that cause interrupts. The first event is when the interrupt routine is triggered on every scan line — or 15,734 times per second — by connecting the composite sync output of the LM1881 chip to the RB0 line on the 16F877 microprocessor. RB0 (Pin 33) is configured in the software to cause an interrupt on a negatively going edge. Here one must consider timing. The horizontal scan rate is 15,734 Hz which means that an interrupt will occur every 63.5 microseconds. With an instruction cycle time of 0.200 microseconds, the maximum number of instructions in the interrupt subroutine is limited to 320 instruction cycles. For most interrupts, timing is not a problem, but when scan-line

data is being dumped onto the screen or an input character is being processed, the timing is going to be tight.

When the interrupt is entered, the routine first checks to see if the cause of the interrupt was a horizontal sync pulse. This is done by checking the INTF bit in the INTCON register. The logic for a horizontal sync pulse interrupt is shown in Figure 2. The routine next checks to see if the vertical retrace is active on RB1 (Pin 34). If the vertical retrace is active — as indicated by a zero level on the vertical sync pulse — then the horizontal line count, HSYNC_COUNT1, is set to zero.

If the vertical retrace is not active, then the horizontal line count is incremented and compared to the line count where the text should start, START_LINE_C. If START_LINE_C is equal to the horizontal line count, then the DISPLAY_ACTIVE_BIT is set to TRUE, the character bit row, LINEINDEX1, is zeroed, and the interrupt routine is exited.

The first attempt to write character data to the screen took about 29 instructions per character. This limited the number of characters in one line to about seven. After some careful rewriting, the number of instructions was reduced to 12, as shown in Figure 3. This set an upper limit of about 15 characters across the screen. Because of video memory limitations in bank1, the number of characters was further limited to 13.

The second cause of interrupts is a character being received on the serial input line, RC7 (Pin 26). The interrupt routine checks to see if there is input on the serial line by checking bit RCIF in the PIR1 register. If it is set, then the routine does the following:

1. Clears RCIF, clears backspace flag, and clears serial error LED on RC0 (Pin 15).

2. Checks for serial overflow and framing error and turns on the serial error LED, if necessary.

3. Reads the serial-input character.

4. Outputs the serial-input character.

5. Checks to see if the character received was a backspace, 0x08.

6. If it is a backspace, then change character to space, decrement character pointer, and store. Set backspace flag.

Figure 1. A Program Showing How Scan Data is Stored in Video Memory.

```
ORG 0x200      ;Scan data is obtained from special lookup tables called
ALPHA_DATA  ADDWF PCL, F
        RETLW B'11100000' ; %   ***      % ; @ is replaced with a degree F
        RETLW B'10100000' ; %   * *      %
        RETLW B'11111110' ; %   ******   %
        RETLW B'00001000' ; %       *    %
        RETLW B'00001110' ; %       ***  %
        RETLW B'00001000' ; %       *    %
        RETLW B'00001000' ; %       *    %
        RETLW B'00000000' ; %            &
        RETLW B'00011000' ; %     **     % ; This is A
        RETLW B'00111100' ; %    ****    %
        RETLW B'01100110' ; %   **  **   %
        RETLW B'01111110' ; %   ******   %
        RETLW B'01100110' ; %   **  **   %
        RETLW B'01100110' ; %   **  **   %
        RETLW B'01100110' ; %   **  **   %
        RETLW B'00000000' ; %            %
        RETLW B'01111100' ; %   *****    % ; This is B
        RETLW B'01100110' ; %   **  **   %
        RETLW B'01100110' ; %   **  **   %
        RETLW B'01111100' ; %   *****    %
        RETLW B'01100110' ; %   **  **   %
        RETLW B'01100110' ; %   **  **   %
        RETLW B'01111100' ; %   *****    %
        RETLW B'00000000' ; %            %
…
Video text memory starting at 0x32 contains the characters to be displayed
ABABABABABABA

Each scan line of each character is loaded sequentially into video memory
starting at x0A0.

00011000  End scan line for first character
01111100
00011000
01111100
00011000
01111100
00011000
01111100
00011000
01111100
00011000
01111100
00011000  End of first scan line of last character
00111100
01100110
00111100
01100110
00111100
01100110
00111100
01100110
00111100
01100110
00111100
01100110
00111100 End of second scan line of data
…
Up to 7 scan lines of data
```

7. Verify that the new character address is still in the valid video text memory range. If not, force the address to be in the valid range.

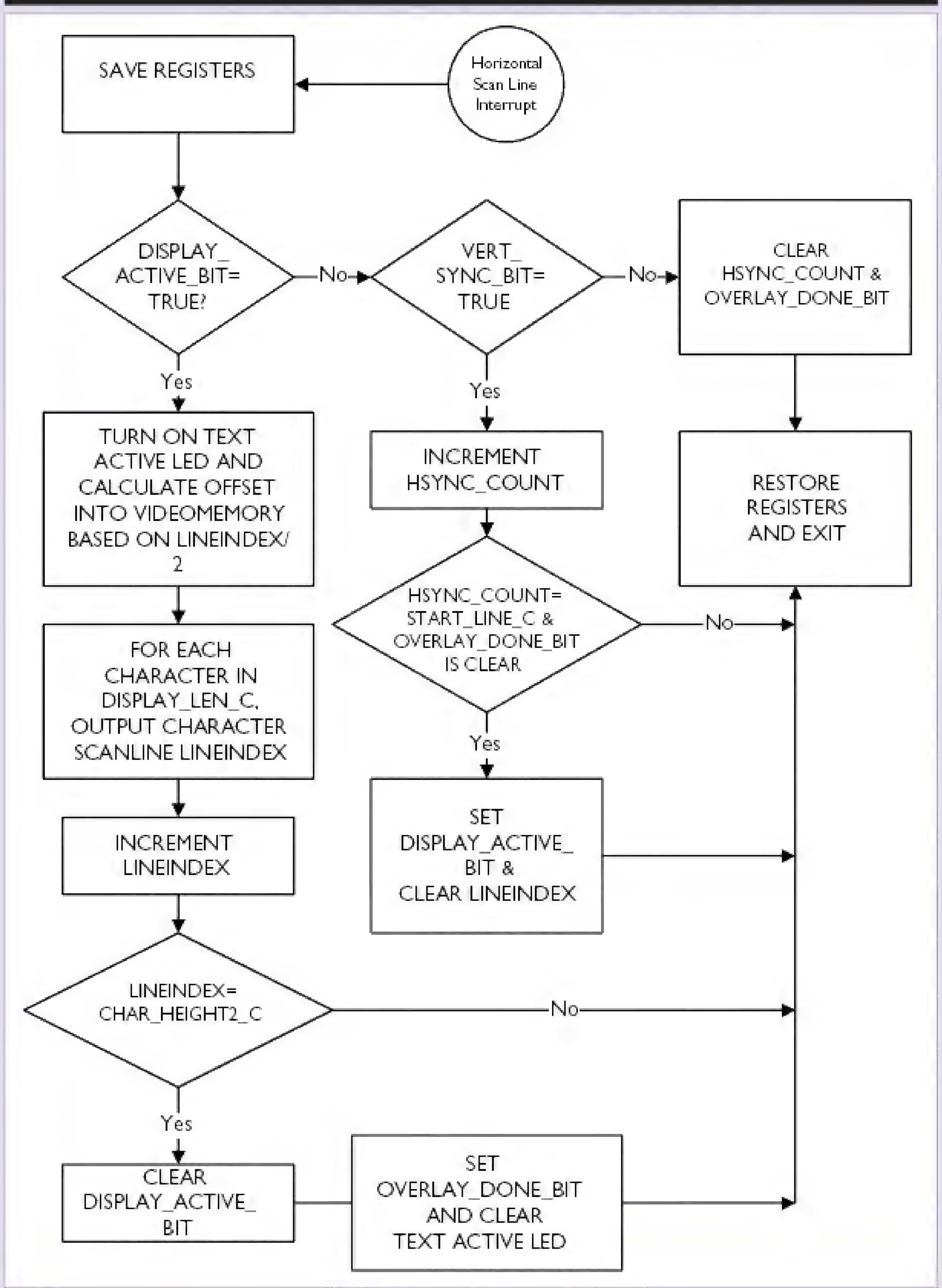
8. If it isn't a backspace, then store and increment the character pointer.

9. Set DISPLAY_UPDATE_REQUIRED flag.

Finally, an interrupt is triggered by the rollover of the 16-bit TIMER1 register. When the timer completes its count up to 65,535 and rolls over to zero, an interrupt occurs. Since the timer is programmed to increment its count every 1.6 microseconds, it takes about 0.1 seconds to overflow.

This interrupt is used with the logic for the subliminal messaging. The program logic will display the subliminal message from MESSAGE_ON_C (the default is four scans, or two frames), which scans approximately every 25 seconds if the NORMAL switch is closed. If the NORMAL switch is open, then the message is displayed continuously on every frame.

Figure 2. Horizontal Sync Interrupt Flowchart.



Programming the Microprocessor

The microprocessor can be programmed using the PIC-PG1 programmer from Reference 3. Shown in Figure 4, the PIC-PG1 is a low-cost, serial-port programmer built into a DB-9 connector and does not need an external power supply since it takes all necessary signals and power from a personal computer's RS232 port. The free MPLAB assembler and software development environment is free from Microchip at **www.microchip.com** and is used to compile the program into a ".HEX" file. It is downloaded to the microprocessor using the programmer. The Flash program memory on the 16F87x microprocessor is electrically programmable and erasable, and the program memory is retained when the microprocessor is powered down.

Final Testing

The first step in testing the PICVIDEO is to make sure the video camera is working and the TV is receiving a good picture. If your television has a video input, you can hook the video output of the PICVIDEO directly to the video input of the TV. If you do not have a video input to your TV, you will have to use an RF modulator, hook up to the antennae input, and tune to Channel 3 or 4. The circuit can be tested with only the video camera and the RF modulator (if used) powered up. The picture on the screen should be normal.

Next, the PICVIDEO is powered up. The picture should now display the message "PICVIDEO V6.0" near the bottom of the screen. The next step is to type in something. You can hook up the device to the RS232 serial port on your personal computer and use a program like HYPERTERM for communication, as shown in Figure 5. The serial port should be set for 19,200,8,E,1. Note that only the characters in Table 1 of Part 1 will be displayed. In addition, a 0x08 byte has been implemented as a backspace in PICVIDEO. If you hit the backspace key or a CTRL-H, the display should back up one space and erase the existing character. If everything is working okay, then, as you type, text should appear superimposed over the picture. By adjusting R4, you can make the characters more or less transparent to the picture, and you should get

```
CLRC ; CLEAR CARRY BIT
    RRF LINEINDEX1,W ; DIVIDE BY 2 SINCE EACH CHARACTER DOT IS TWO SCAN
LINES TALL
    CALL GET_OFFSET ; DOT ROW IN CHARACTER PASSED IN W, MEMORY ADDRESS
OF SCAN LINE DATA RETURNED IN W
    MOVWF FSR     ;FSR CONTAINS ADDRESS OF SCAN DATA IN MEMORY
    MOVLW DISPLAY_LEN_C  ; LOAD TOTAL NUMBER OF CHARACTERS INTO
COUNTDOWN INDEX
    MOVWF CHAR_INDEX1
NEXT_CHAR
; OUTPUT BITS OF ONE ROW OF ONE CHARACTER
      MOVF  INDF,W    ; GET 8 BITS OF DATA FROM VIDEO MEMORY     1CYCLE
      MOVWF PORTD ; OUTPUT BIT 7 THROUGH BIT 7                   1CYCLE
      RLF   PORTD,F ; OUTPUT BIT 6 THROUGH BIT 7                 1CYCLE
      RLF   PORTD,F ; OUTPUT BIT 5 THROUGH BIT 7                 1CYCLE
      RLF   PORTD,F ; OUTPUT BIT 4 THROUGH BIT 7                 1CYCLE
      RLF   PORTD,F ; OUTPUT BIT 3 THROUGH BIT 7                 1CYCLE
      RLF   PORTD,F ; OUTPUT BIT 2 THROUGH BIT 7                 1CYCLE
      RLF   PORTD,F ; OUTPUT BIT 1 THROUGH BIT 7                 1CYCLE
      RLF   PORTD,F ; OUTPUT BIT 0 THROUGH BIT 7                 1CYCLE
;END BITS OF ONE ROW OF ONE CHARACTER
      INCF FSR,F ; INCREMENT CHAR POINTER                        1CYCLE
      DECFSZ CHAR_INDEX1,F ; HAVE ALL CHARACTER BEEN DISPLAYED   1CYCLE
      GOTO NEXT_CHAR                                           ; 1CYCLE
;ONE SCANLINE COMPLETE HERE                                      ======
;                                                                12
INSTRUCTION CYCLES PER CHAR

; INCREMENT CHARACTER SCANLINE COUNT
      INCF   LINEINDEX1,F
      MOVF   LINEINDEX1,W
      SUBLW  CHAR_HEIGHT2_C
      BNZ    POP    ; MORE SCAN LINES OF DATA TO DO SO JUST EXIT
INTERRUPT

; LAST LINE OF DISPLAY DONE SO CLEAR DISPLAY_ACTIVE_BIT
      BCF  FLAGS1,DISPLAY_ACTIVE_BIT
; LAST LINE OF DISPLAY DONE FOR THIS FRAME, SO SET OVERLAY_DONE_BIT
      BSF  FLAGS1,OVERLAY_DONE_BIT
```

Figure 3. Coding to Output One Scan Line of Data.

a picture that looks like Figure 7.

Remember that the PICVIDEO uses the sync information from the video picture to time the output of the text to the screen. No picture means no text.

Subliminal Messaging

Now that we have a system that can superimpose text on a video picture, let us explore the world of subliminal messaging. A subliminal message is one that is displayed for a short time, normally one frame, or a 30th of a second, so that it does not register with the conscience mind. I am a skeptic in this area, but the Federal Communication Commission (FCC), in a 1973 investigation, did determine that an advertiser for the boardgame Hüsker Dü had broadcast a subliminal message "Get It" in a television commercial.

The Television Code of the National Association of Broadcasters, which inspired the codes used by many stations, prohibits the use of "any technique whereby an attempt is made to convey information to the viewer by transmitting messages below the threshold of normal awareness ..." So, someone believes it works.

In 2000, a commissioner of the FCC said, "The FCC has no formal rules on the use of 'subliminal perception' techniques. In fact, the Commission appears to have addressed the issue only twice. In 1974, the agency issued a policy statement that the use of 'subliminal perception' is 'contrary to the public interest.' But policy statements are not enforceable rules. Nor would it be appropriate for the Commission to fine a person for failure to comply with a policy statement."

The Federal Trade Commission seems to want to have it both ways, saying that "it would be deceptive for marketers to embed ads with so-called subliminal messages that could affect consumer behavior. However, most consumer behavior experts have concluded that such methods aren't effective." Essentially, they're saying it would be bad if advertisers did subliminal messaging, but we don't believe it works.

The problem with measuring the effectiveness of something that is "below the threshold of normal awareness" is that one is dealing with the sub-conscious mind and effective standards for measurement have not been developed. There is National Institute of Mental Health (NIMH)-sponsored research in visual "subliminal" stimuli at the University of Washington to test for possible cumulative effects of several types of repeated subliminal visual presentations. They are trying to develop a diagnostic procedure that can provide comparative appraisal of different attitude conditioning procedures.

Figure 5. Using HYPERTERM to Change a Message in PICVIDEO.

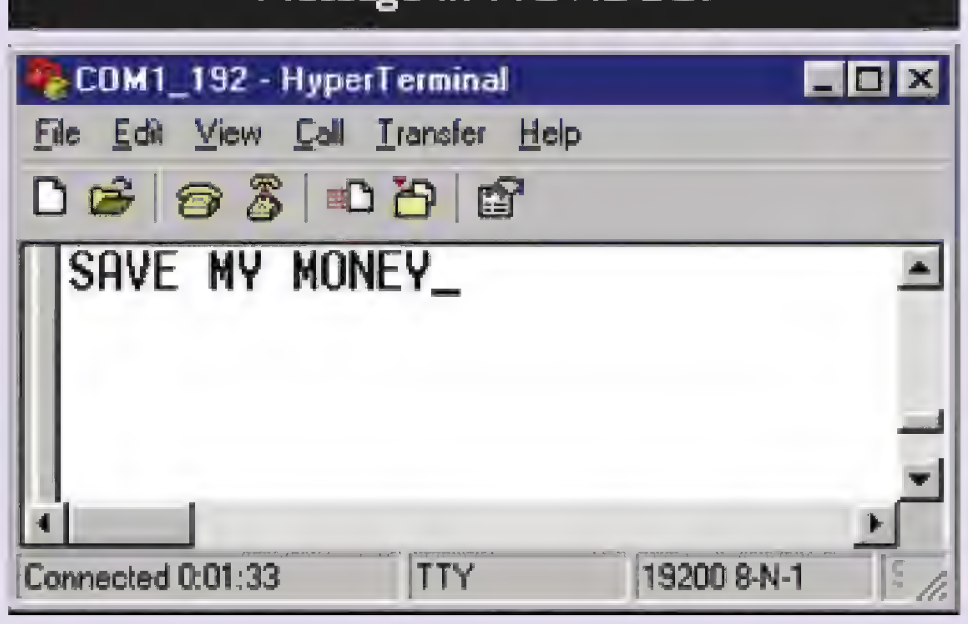


Figure 4. Programming the Microchip 16F877.

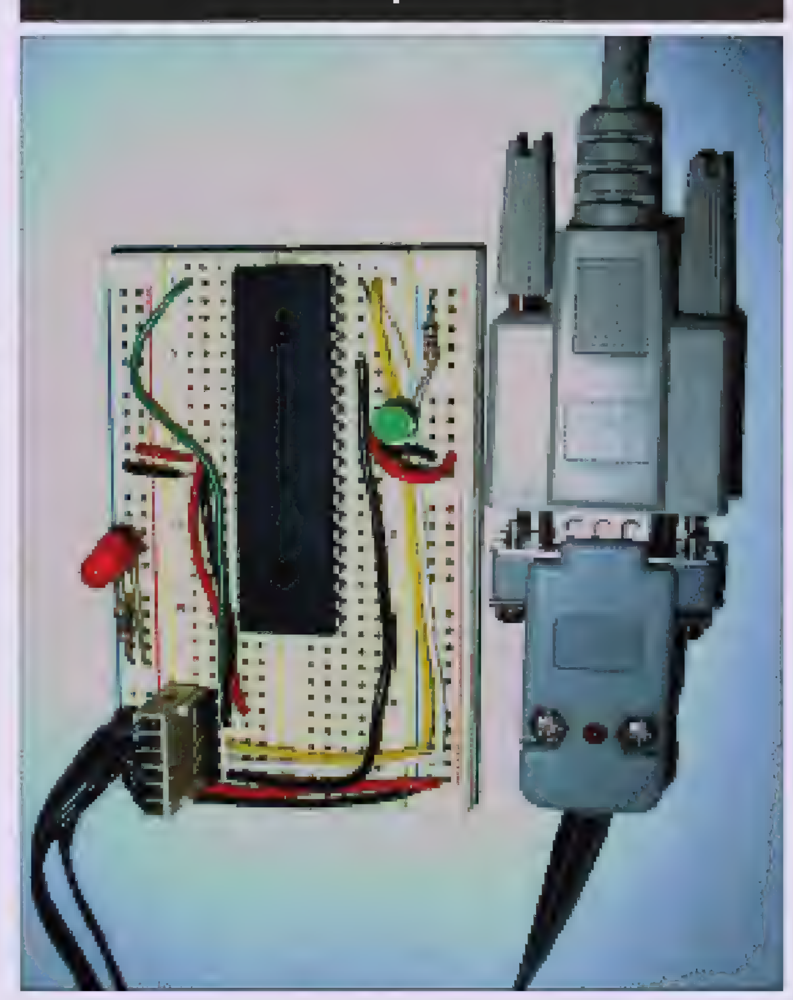


Figure 6. PICVIDEO with User-entered Text.

Figure 7. A Working PICVIDEO Screen Shot.

The subliminal messaging logic in the PICVIDEO is controlled by the NORMAL switch. With this switch open, text is displayed continuously on the TV, superimposed on the picture. With the NORMAL switch closed, the TIMER1 and a countdown register are used to display a message approximately once every 25 seconds. The message is displayed for MESSAGE_ON_C scans. The default is four scans, and the STARTUP_LED is on while the message is being displayed.

Subliminal messaging appears to be one of those areas where there is no definitive scientific proof. If you want to try an experiment, here are some tips for making your subliminal message more effective.

1. The message should be in the first person (using I or me).

2. The message should be in the present tense.

3. The message should be positive but not just the reverse of a negative.

Here are some good examples to try: I am happy, I am succeeding, I am a nice person, I am positive, I am in control of my life, I am achieving my goals, I am motivated and people like me. Try it for what it's worth; it can't hurt.

Conclusion

We have reduced the 68 integrated circuits in the TV typewriter to three. While the TV typewriter is functional, more useful applications include superimposing information — such as the time or temperature — on video information. In that application, you would use the microprocessor to read a temperature sensing device or real-time clock and build the string of ASCII characters in the video text memory (0x35 to 0x41). The unit can also be used to try some interesting experiments in subliminal messaging. Significant others beware! **NV**

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ABOUT THE AUTHOR

Robert Lang is a professional electrical engineer interested in embedded microprocessors, MIDI, and music. He has written several articles for electronic hobbyist, computer, and synthesizer magazines. He can be reached at rlang@netdoor.com or by a Google search for "harpsitron."

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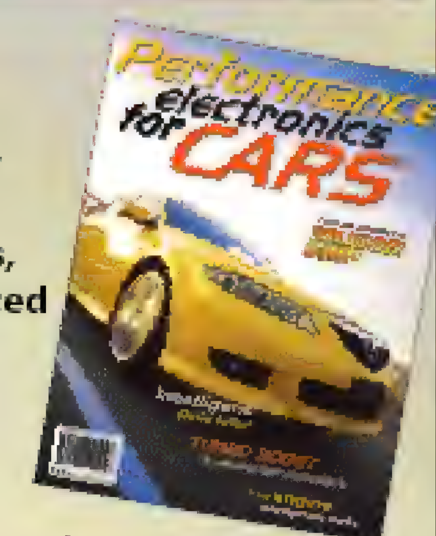

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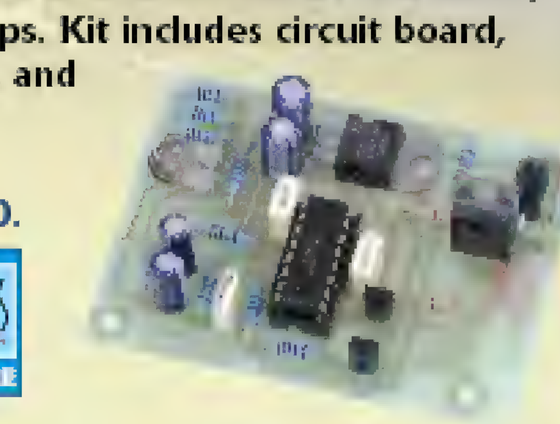

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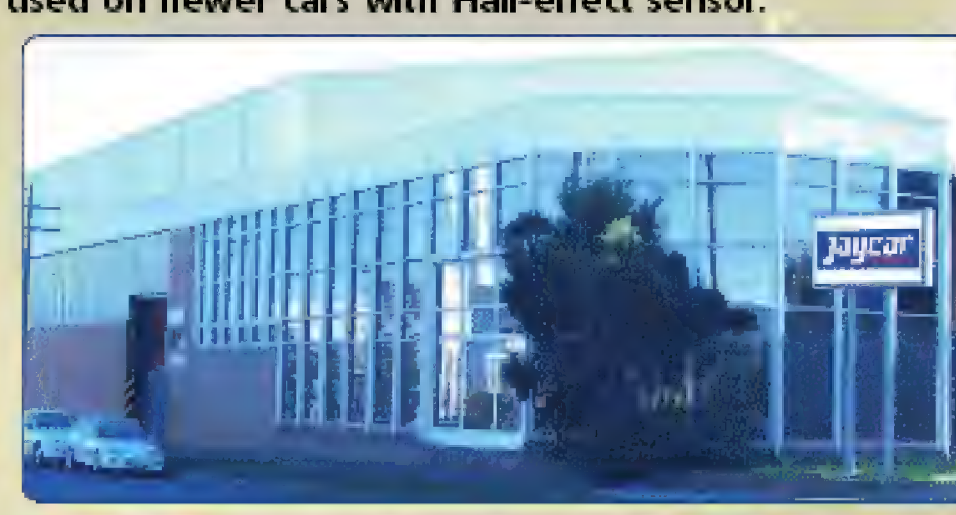

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Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

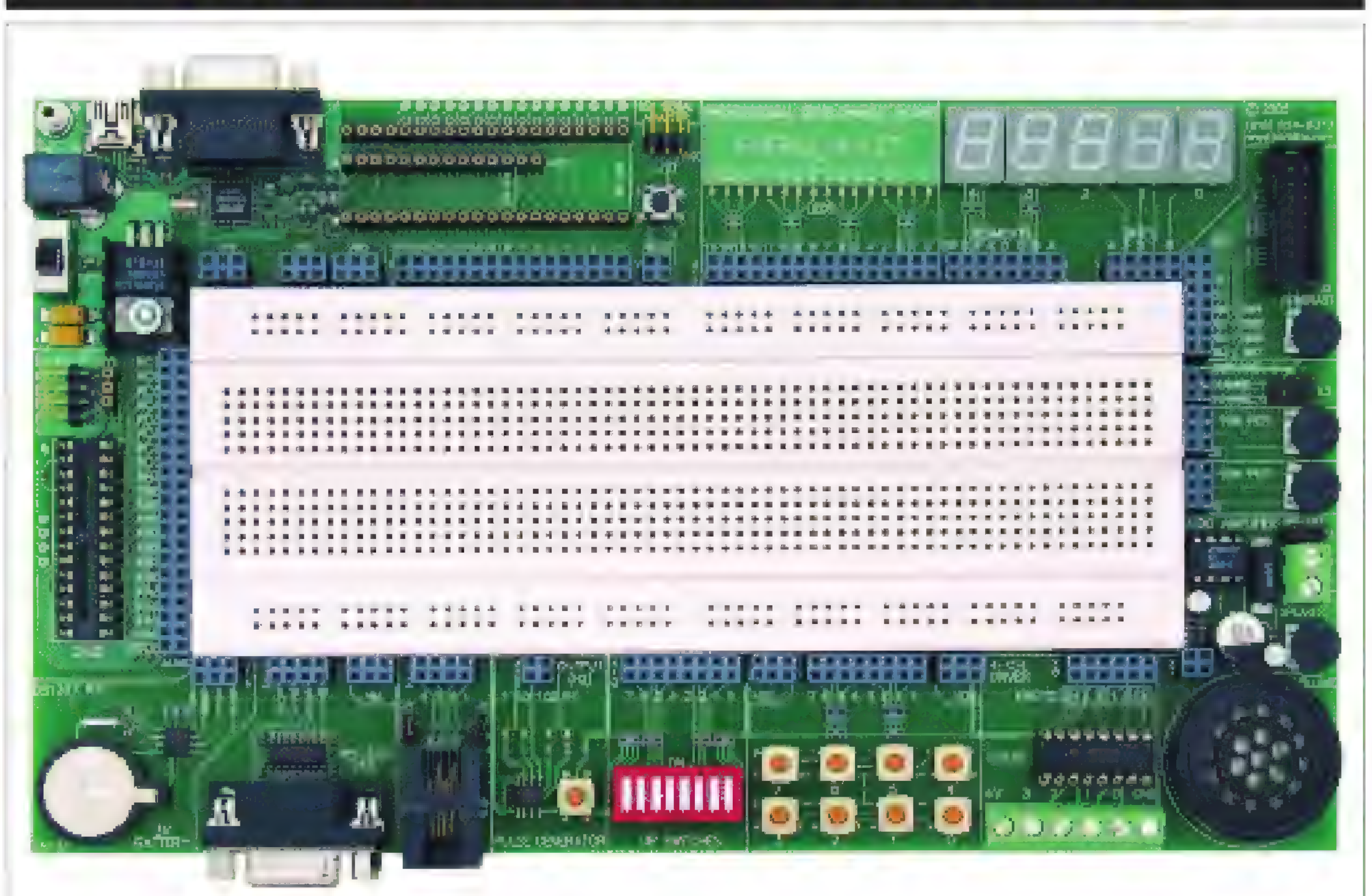
Stamp Applications

The Parallax PDB — Freedom to Create

When I first started working for Parallax my boss, Ken, handed me a big development board and said, "See what you can do with this." The board was, of course, the original NX-1000, and Ken and I went on to create StampWorks around it. Even after StampWorks, the NX-1000 never left my desk; it was the perfect "playground" for my experiments, and many of my projects for this column originated on the NX-1000 development board.

The NX-1000 went through a series of improvements and ultimately ended up as two versions: a standard model and one that supported 40-pin BASIC Stamp modules. Not too long ago, my colleague, John Barrowman, was working with an NX-1000 and felt like there was an opportunity to integrate all the features we liked in the existing models plus a few new tricks. John was right, and after a lot of hard work and feedback from me and the other "power users" in the office, the Professional Development Board (PDB) was born. Figure 1 shows the PDB in all its glory.

Figure 1. The Parallax Professional Development Board.



In a simple word, the PDB is stellar; it has become my favorite development platform, and you'll see why as I work through its features. And don't get caught up on the term "Professional" in its moniker; that's referring to its professional features not the price tag. As a matter of fact, the price of the PDB is actually lower than the NX-1000, and we can thank the engineering and manufacturing folks at Parallax for delivering such a great platform at such a reasonable price (about $150.00).

And just a note to my friends who are using "the other guy's" 24-pin microcontrollers (products like the OOPic and BX-24): I think the PDB will work fine for you too. Please, try before you buy because Parallax hasn't tested the programming connections with anything but their own products.

Modules, Modules, Modules

What really excites me about the PDB is that I can develop projects for any of the microcontroller modules that I would normally work with: the BS1 (SIP version), the BS2 family (24- and 40-pin versions), the Javelin Stamp, and even the SX28. Even better, when using the BS1 or a 24-pin Stamp module, the SX28 can be used at the same time. Remember the LED controller I did back in January using the SX28? I built and tested that project with a BASIC Stamp master on a very early prototype of the PDB. The only caution one must take regarding the SX28 is when you want to work with the BS2p40. The AUX lines of the BS2p40 share the same terminals as the RB and RC ports of the SX28. So, if you want to use the BS2p40, be sure you remove the SX28 first so that there is no conflict with the I/O pins. Figure 2 shows how you can mix and match the various microcontroller modules.

The next logical question is about programming ports; the PDB has four — yes, four: a USB serial port, a DB-9 serial port, a three-pin header for the BS1 Serial Adapter, and a four-pin header for the SX-Key. Figure 3 shows the programming connections and how they work with the various modules. Suffice it to say, the PDB has all the programming connections we'll need to get the task done; just note that the USB and DB-9 programming con-

nections cannot be used at the same time.

Parts Galore

Like its cousin the NX-1000, the PDB has a whole host of support components that make project development a breeze. When we need something that is not actually part of the PDB, there's a full-sized solderless breadboard that gives us ample space for extra components.

Here's the complete list of the on-board connections and support components, as they appear on the PDB, moving clockwise from the upper left-hand corner:

	BS1-IC	BS2-24	BS2-40	Javelin	SX28
BS1-IC		×	×	×	✓
BS2-24	×		×	×	✓
BS2-40	×	×		×	×
Javelin	×	×	×		✓
SX28	✓	✓	×	✓	

Figure 2. Module Compatibility.

	USB	DB-9	BS1-SA	SX-Key
BS1-IC	✓		✓	
BS2 Family	✓	✓		
Javelin Stamp	✓	✓		
SX28AC/DP				✓

Figure 3. PDB Programming Connections.

- USB port (programming)
- DB-9F (programming)
- 24/40-pin socket
- 14-pin SIP socket (BS1-IC)
- Three-pin BS1 port (programming)
- Reset button
- (16) discrete LEDs
- (5) seven-segment LEDs
- Parallel LCD connection
- (2) three-pin servo headers
- (2) 10K pots
- LM386 audio amp
- L293D push-pull driver
- (8) active-low pushbuttons
- (8) active-low DIP switches
- Pulse generator
- RJ-11 connector
- DB-9F serial connector
- DS1307 RTC
- SX28AC/DP socket
- Three-pin socket for SX resonator
- Four-pin SX-Key header
- Power switch
- 2.1-mm power input

Yep, that's a whole lotta good stuff, and remember that this surrounds a large breadboard. Since most of those components are commonplace and we use them day-in and day-out, I don't need to get into any real detail, but let's do cover the essentials:

LEDs: The 16 discrete LEDs and five seven-segment LED modules are blue. There's nothing magic, they just look doggone cool. All LEDs are active high, so for the seven-segment displays, you will enable a digit by pulling its common-cathode line low.

LCD Port: This is a standard 2 x 7 box header that we can use with common LCDs. One thing of note is that the socket for the signal lines splits the LCD bus: The DB0-DB3 pins (not used in four-bit mode) are on the left, and the DB4 to DB7 lines are on the right. If you look very closely at Figure 1, you can see the markings adjacent to the connector. Keep this in mind when you're making LCD connections. You can use either four-bit or eight-bit mode, you just have to use the appropriate connections in the socket.

Servo Ports: There are two three-pin headers that can be used with servos or devices that follow the same connection layout (Signal-Vdd-Vss). For example, the Parallax Serial LCD module or PING))) sonar sensor could be connected to these ports using a standard servo extender cable.

Pots: There are two 10K pots with all the connections made available. And if you look very closely, you'll also see a small resistor (220 ohm) inline with the wiper connec-

tion. This is one of the nice features John built into the PDB. This resistor prevents the accidental connection of an I/O pin directly to Vss or Vdd; a connection that when coupled with a programming error could damage the Stamp or SX. This feature makes the PDB "expert proof." Come on, admit it, we've all made wiring errors and damaged components; that's less likely with the PDB.

Audio Amp: This is a fairly standard LM386 audio amp circuit with a built-in filter that makes it suitable for the **SOUND** (BS1), **FREQOUT**, and **DTMFOUT** instructions. A small speaker is built right into the PDB, but if you want more volume, you can move the speaker jumper to EXT and connect a small eight-ohm speaker. I use a nice little bookshelf speaker from RadioShack®, and it sounds great.

L293D: The NX-1000 used the ULN2803 for high-current outputs, while the PDB has changed to the L293D. The nice thing about the L293D is that it's a push-pull driver (sources and sinks current on outputs); the ULN2803 only sinks current. The ability of the L293D to source and sink current gives us more flexibility, and the channels can be combined to form an H-bridge circuit. Since the L293D is new (to me), we'll do a simple project with it after we get through the parts description.

Pushbuttons: The PDB has eight, active-low pushbuttons (each I/O pin gets pulled to Vdd through 10K). As with the 10K pots, the pushbutton circuits have inline 220-ohm resistors to protect I/O pins.

DIP Switches: The eight, active-low DIP switches are electrically identical to the pushbuttons.

Pulse Generator: The PDB pulse generator is identical to that on the NX-1000, in that it provides a 50 percent duty cycle pulse at 1 Hz, 10 Hz, 100 Hz, or 1 kHz. A pushbutton is used to set the output frequency.

RJ-11: This connection has configuration jumpers so that it can be used with the iButton® "Blue Dot Receptor" modules (for **OWIN** and **OWOUT**), as well as X-10 transmitter modules (for **XOUT**).

DB-9F Serial Port: As with the early version of the NX-1000, this lets us connect to off-board serial devices. The level-shifter gives us TX, RX, RTS, and CTS lines, which means we can implement full-flow control (important for many projects).

DS1307 RTC: This is the same I^2C™RTC that is used on the NX-1000-24/40. A lithium backup cell is included.

All in all, this is a very nice complement of components and flexibility and does indeed give us the freedom to create to our hearts' desire. As much as I like my NX-1000 boards, the PDB has replaced them as my favorite development tool. I think when you give it a try it will be yours, too. Okay, enough chit-chat, right? Let's do something.

Steppin' Out With the L293D

Stepper motors are fairly easy to control with the BASIC Stamp, and with the L293D we can now control either unipolar (five- or six-wire) or bipolar (four-wire) stepper motors. This is very cool. I frequently find low-cost bipolar steppers at Tanners, and now I can put them to use. And here's even better news: The same program will control either motor type!

That last part really made me smile. I had never used a bipolar stepper before, so I did a little Googling to see what I was getting into. Imagine my surprise, when I found the step table for bipolar steppers exactly matched what I was already doing with unipolar motors. Now, I'm a "show me" kind of guy, so I tried ... it worked! ... way cool!

For fun, I'm going to present the program for the BS1, though it is super easy to modify for the BS2. Why the BS1? Well, I've been spending a lot of time with the BS1 lately. In February, John and I went to a Halloween-oriented convention called Death Fest (**www.deatfest.net**). It turns out that there are lots of interesting folks that build Halloween (and other holiday) displays, and many use the BS1 to control things. In fact, there were so many and their needs were so specific that John and I created a repackaged version of the BS1 called the Prop-1 Controller. It's a BS1 core with an onboard ULN2803 and a few other features that help prop and FX builders.

So, contrary to the belief by some, the BS1 is not dead. In fact, the 2.1 version of the BASIC Stamp editor handles the BS1 very nicely, adding the Memory Map feature that used to be restricted to the BS2. The Memory Map is really important for the BS1 as its EEPROM space is so small. The other thing that I like is that it will remind me that I can't use W6 for variable space when I declare subroutines (because W6 gets used as the **GOSUB-RETURN** stack).

Okay, onto the stepper code. Since the program is very short and we haven't used the BS1 is a long time, I'm going to go through every part of the program in some detail. This will get you back into the saddle with the BSI or, perhaps, get you interested if you haven't used it in the past.

Let's look at the declarations first. In the BS1, everything is declared as a **SYMBOL**; I/O pins, constants, and variables.

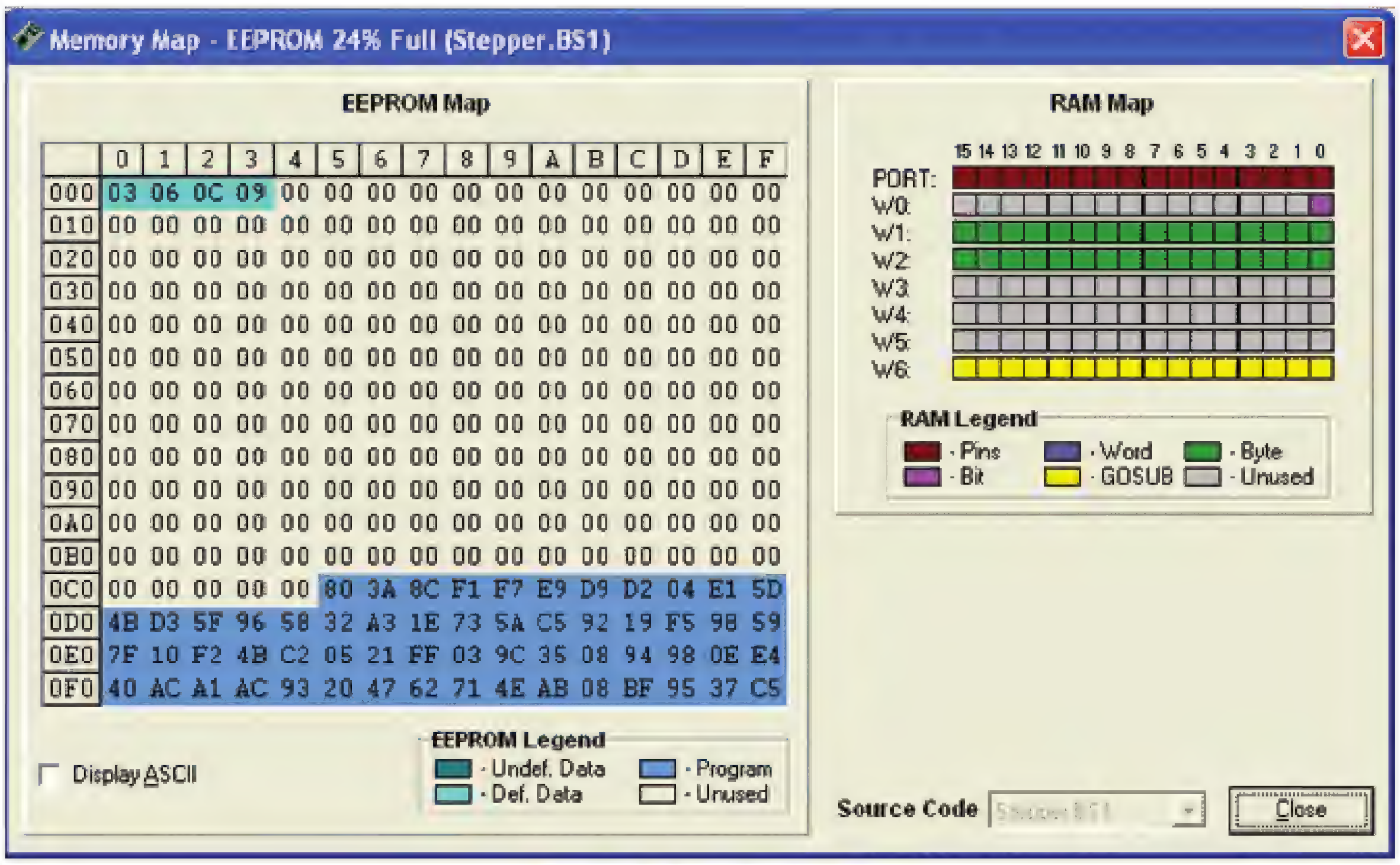


Figure 4. Memory Map.

```
SYMBOL  Stepper         = PINS
SYMBOL  ChngDir         = PIN7

SYMBOL  StpsPerRev      = 48
SYMBOL  NotPressed      = 1
SYMBOL  Pressed         = 0
SYMBOL  CW              = 0
SYMBOL  CCW             = 1

SYMBOL  rotation        = BIT0
SYMBOL  idx             = B2
SYMBOL  phase           = B3
SYMBOL  stpIdx          = B4
SYMBOL  stpDelay        = B5
```

The BS1 does not have separate names for the output and input registers (OUTS and INS in the BS2); there is a register called PINS that is contextually sensitive. When we write a value to PINS, that value goes to the output register, and when we read a value from PINS, we're getting that value from the input register.

Notice that the declaration for Stepper uses the entire PINS register. We need to do this as there is no way to split PINS into nibble-sized groups. Since our program actually needs just four pins for the stepper outputs, we'll use a mask to protect the pins not connected to the motor. More on that later.

The PINS register can, however, be declared as individual bits. For this program, we're going to use a pushbutton to set the rotational direction of the stepper; we'll connect this button to P7, hence the PIN7 declaration for ChngDir. Note that some commands in PBASIC 1.0 require the pin number as a constant value, so keep that in mind when declaring symbols for I/O pins and be sure to double-check the help file as to whether a command wants an I/O register variable (e.g., PIN5) or the pin port number (e.g., 5).

As you can see, constants are very easy to define: we simply put the symbol's value after the equal sign. The BS1 does allow 16-bit values (like the BS2), so a constant can have a value from zero to 65535.

Finally, we should declare variables with meaningful names, and this can be the trickiest thing to do with the BS1. In the BS1, we have to manually assign our variable names to a specific location in RAM. For most programs, we will be using byte variables, so I recommend that you start your definitions at B2. Why? Well, the BS1 only lets you deal with 16-bit-sized variables, and those are attached to W0 (B0 and B1). If we start our byte definitions at B2, then the bit variables will be available if/when we need them. For example, the original version of the stepper program didn't have the reverse button. Adding the button and the rotation variable to keep track of direction was no trouble because neither B0 nor B1 had been previously assigned.

I know what you're thinking: "If I have to map variables manually, why don't I just use the built-in RAM names?" It's tempting, I know, but I can't even begin to remember how many customer programs I've fixed that had crossed-up variables because the internal names were used. Don't do it ... don't go to the dark side ... it just takes a few minutes to define useful names, so trust me and just do it.

For review, we can have BIT0 to BIT15, B0 to B12, and W0 to W6. Not a lot of variable space, I know, but then we don't have a lot of code space either so it's usually not a problem. Just remember that BIT0 to BIT7 occupy the same space as B0, which is actually the low byte of W0. Now you can see why the Memory Map is so important for the BS1. Figure 4 shows the Memory Map for the stepper program. Note how W6 is colored yellow to indicate its use for **GOSUB-RETURN**. If we attempt to assign a variable to W6 (or B11 or B12), the Memory Map will show yellow with a red slash to indicate a conflict. This issue only comes up when using **GOSUB-RETURN** — if that doesn't exist in a program then we are free to use the W6 RAM space.

I tend to separate my setup from the main loop code to keep things organized. In this program, there are just two things to do: initialize the motor pins to be outputs and set the motor speed.

```
Reset:
  DIRS = %00001111
  stpDelay = 3
```

There's no magic here: The BS1 has a DIRS register just like the BS2. The difference being that the BS1 register is only eight bits wide. The variable called stpDelay (delay between steps), affects how fast the motor turns;

the smaller the value, the faster it turns.

And now we get to the heart of the program. The logic is straightforward: check the change-of-direction input; if it's pressed, we'll invert the rotation flag, wait for the button to be released, and finally jump to the code that rotates the motor in the current direction. If the change-of-direction button isn't pressed, we jump right to rotating the motor.

```
Main:
  IF ChngDir = NotPressed THEN Move_Motor
  rotation = rotation ^ 1

Force_Release:
  IF ChngDir = Pressed THEN Force_Release

Move_Motor:
  IF rotation = CCW THEN Turn_CCW

Turn_CW:
  GOSUB Step_Fwd
  GOTO Main

Turn_CCW:
  GOSUB Step_Rev
  GOTO Main
```

If you're not accustomed to BS1 code, the first thing that stands out is the number of program labels. The BS1 doesn't have the **IF-THEN-ELSE** construct, so we have to apply a bit of inverted logic to get **IF-THEN** to flow smoothly. It's not difficult, it just takes a little planning (very little!). I think that one read-through of the code will make perfect sense and, if you take away nothing else, please note that the use of appropriately named constants and variables makes the program very easy to follow. This is why I get so adamant about defining meaningful symbols — it makes the rest of our work easier.

The final section holds the subroutines to actually move the motor. This code is pulled out as subroutines (instead of being buried in the main program loop) so that it can be used in other programs.

```
Step_Fwd:
  stpIdx = stpIdx + 1 // 4
  GOTO Do_Step

Step_Rev:
  stpIdx = stpIdx + 3 // 4
  GOTO Do_Step

Do_Step:
  READ stpIdx, phase
  Stepper = Stepper & %11110000 | phase
  PAUSE stpDelay
  RETURN
```

There are two separate subroutines for movement, but their purpose is the same: calculate the next step in the sequence so that we can pull the coil data from a table. The key to both of these routines is the modulus operator (//). I love modulus; my boss, on the other hand, hates it. Okay, hate is a strong word. Let's just say the modulus operator is not his favorite. Don't worry, I'm still working on him.

Modulus is really quite simple: It returns the remainder of a division. In practice, this means that the modulus operator will return a value between zero and the divisor minus one. In our program, for example, we're going to control the stepper with four whole steps, so we'll want to keep the table index between zero and three. The modulus operator is perfect for this. To point to the next position in the table, we'll add one to the index and then take the modulus of four. The fact that the modulus will cause a wrap-around to zero when we get to the end of the table is particularly useful. Without modulus, we'd have to do this:

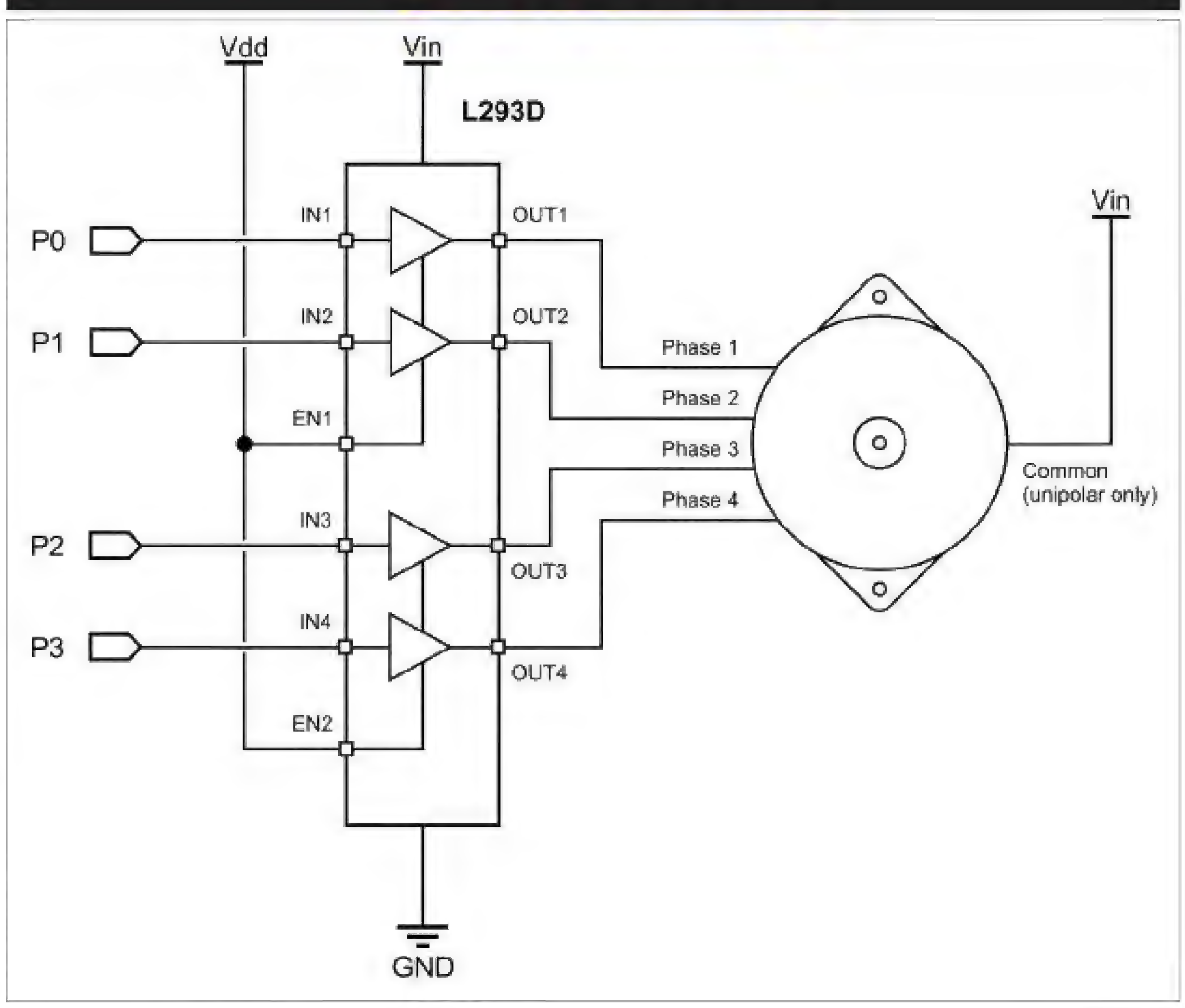
```
stpIdx = stpIdx + 1
IF stpIdx < 4 THEN Do_Step
stpIdx = 0
GOTO Do_Step
```

Do you see how much easier using modulus is? Going backward is the same but requires just a little bit of thinking. Instead of adding one, we're going to add the value of the divisor minus one (three in our program as the divisor is four). Let's look at real values to be clear:

```
0 + 3 = 3 ... 3 // 4 = 3
3 + 3 = 6 ... 6 // 4 = 2
2 + 3 = 5 ... 5 // 4 = 1
1 + 3 = 4 ... 4 // 4 = 0
```

With the new index in place, we will read the coil data

Figure 5. L293D Connections.



	+V	Ph 1	Ph 2	Ph 3	Ph 4
Unipolar	Red	Black	Orange	Brown	Yellow
Bipolar	N/C	Red	Orange	Yellow	Brown

Figure 6. Stepper Connections.

from a table. Here's how that's defined:

```
Full_Steps:
  EEPROM 0, (%0011, %0110, %1100, %1001)
```

Note that we can place a table at the specific location (first value after **EEPROM**), but we can't use program labels to define table locations. We have to keep track of them manually. That's not a problem here, as we only have one table.

Have a look at the subroutine called Do_Step; this does the actual work. The first line uses **READ** to retrieve coil data from our EEPROM table. The next line writes this data to the stepper while preserving the condition of P4 to P7. This is done with a mask value (%11110000). Since the upper four bits of the mask are ones, and we're using the AND operator (&), the current values of those pins will be preserved. With the lower four bits of the mask being zero, the coil outputs will be cleared. The last part of that line adds the new coil data to the outputs.

Finally, the speed control variable, stpDelay, is used with **PAUSE**, and then the process starts all over again.

Getting Connected to the PDB

Now that we've worked through the code, I should probably give you a couple hints about connecting your stepper to the PDB. The connections between the Stamp and the L293D inputs are obvious; P0 to P3 connects to INPUTS 0 to 3 on the PDB (IN1 to IN4 on the L293D). There are two enable pins, and we need to pull both high to enable the outputs (each enable pin controls two outputs; when low, the respective outputs go to a Hi-Z state). Power for the motor is routed from the Vin pin (by the secondary RS-232 port) to the +V terminal near the L293D. Using an external +V connection lets us supply a voltage appropriate for the motor we'll connect.

The last step is to connect the stepper. With a unipolar motor, we will connect the phase connections to the L293D outputs and the common wire to +V. With a bipolar motor, we simply connect the coils.

My unipolar motor is made by Mitsumi and is marked M42SP-5. You can get this motor from Parallax. The bipolar motor is made by Minebea and is marked 17BB-H132-11. I bought mine at Tanners in Dallas, TX, but I've seen them online with surplus dealers. The schematic for the circuit is shown in Figure 5, and the color codes for the motors I tested are shown in Figure 6.

Before I wrap it up, let me share a hint about bipolar steppers that I found during my research. You can follow these steps when you don't know which wire corresponds to which coil (phase):

- Connect the wires in any order.
- Run the program, if it works, you're done.
- If not, reverse the outer two leads (Ph1 and Ph4).
- Run the program. If it works, you're done.
- If not, reverse the inner two leads (Ph2 and Ph3).
- The program will now work.

I actually used these steps with my motor and did, in fact, have to go to the very end. It did work, though, and saved me a lot of trouble experimenting.

That's it for this month. Have fun with the PDB and the microcontroller of your choice and, until next time, Happy Stamping. **NV**

Resources
Jon Williams
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Temperature/Humidity Logging
RH-02/PT104 - Temperature and Humidity Logger for PC. High resolution and accuracy. No power supply required. from $256/600!
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K3 9p-9p isolated RS-422/485
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Approaching the Final Frontier

Near Space

The Thermal Test Chamber

Got a new item for near space that you want to test? Simple tests on the ground can ensure that your design functions well in near space. This way, failures identified during a test can be corrected before a near-space flight (where a failure can lead to the loss of a near spacecraft).

One of the simplest tests is the thermal test. It's cold in near space, and as the chart in Figure 2 indicates, it can drop to minus-60 degrees F during a mission. I have seen at least one camera and several batteries fail because of the cold temperatures in near space.

The thermal test chamber (TTC) I will describe here (see Figure 1) has tested several of my BalloonSat designs. However, this TTC is not just for near space testing. It's also for testing weather stations or other sensors that you'll leave to the elements.

Materials

Many people have made a TTC by tossing a chunk of dry ice into a Styrofoam ice cooler. I'm not happy with that design because the sides of the TTC aren't straight, the walls aren't thick, and it limits the selection of volumes. Instead, I designed a thick-walled Styrofoam box to my own dimensions and added fans. I figured this would let me use the interior volume more effectively and create colder temperatures. Besides, it's easier to make a square box look high tech than it is to make a beer cooler look high tech.

I used the following materials to make my TTC:

- Two-inch-thick Styrofoam sheet
- Half-inch-thick Styrofoam sheet
- X-acto Knife (with two-inch-long blade)
- Metal yardstick
- Pencil
- Hot glue
- Space blanket
- Aluminum tape
- 1/8-inch modeling plywood
- Miniature CPU fans (2)
- #22 AWG stranded wire
- 1/8-inch heatshrink tubing
- Packing tape
- #4-40 hardware (four sets)
- Five-volt wall-wart power supply
- Power plug
- Desk top letter boxes (three)

Procedure

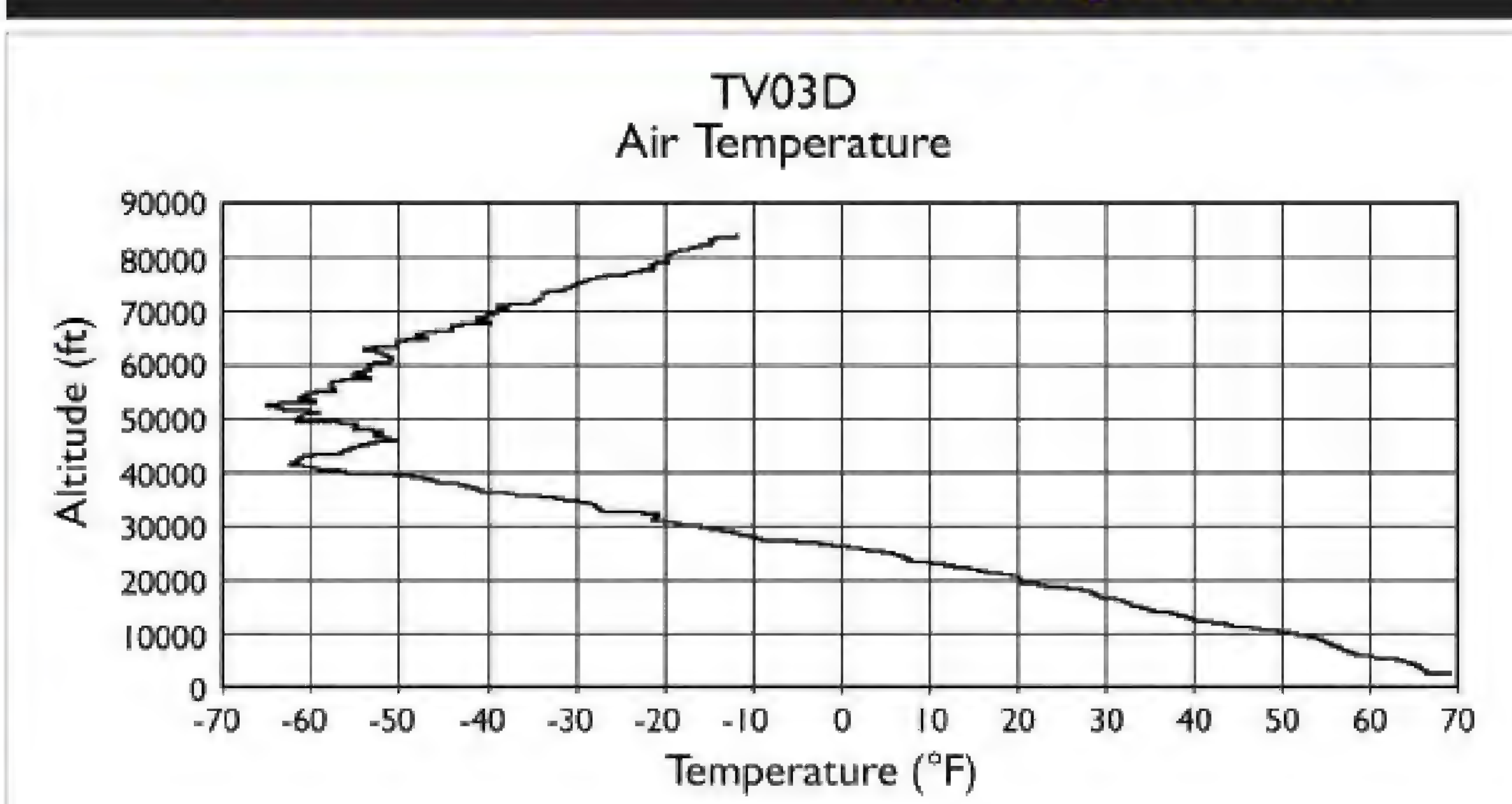
My TTC is a cube measuring about 18 inches on each side. This is large enough to hold the dry ice in a cage and test two BalloonSats. Feel free to assemble a TTC with different dimensions. However, be aware that if you make your TTC larger, you'll need to use larger fans and charge it with more dry ice.

Begin by laying out the sides of the TTC on the two-inch-thick Styrofoam. Use a pencil and metal yardstick to draw the lines. Then use the yardstick to guide the X-acto knife as you make each cut. Styrofoam cuts cleanly with a sharp X-acto knife blade.

Make several cuts through the Styrofoam with the blade held at as shallow of an angle as you can. The cut edge of the Styrofoam should be smooth. If the knife breaks out chunks of Styrofoam, then the blade

Figure 1. The completed thermal chamber.

Figure 2. Outside air temperature is compared against altitude.



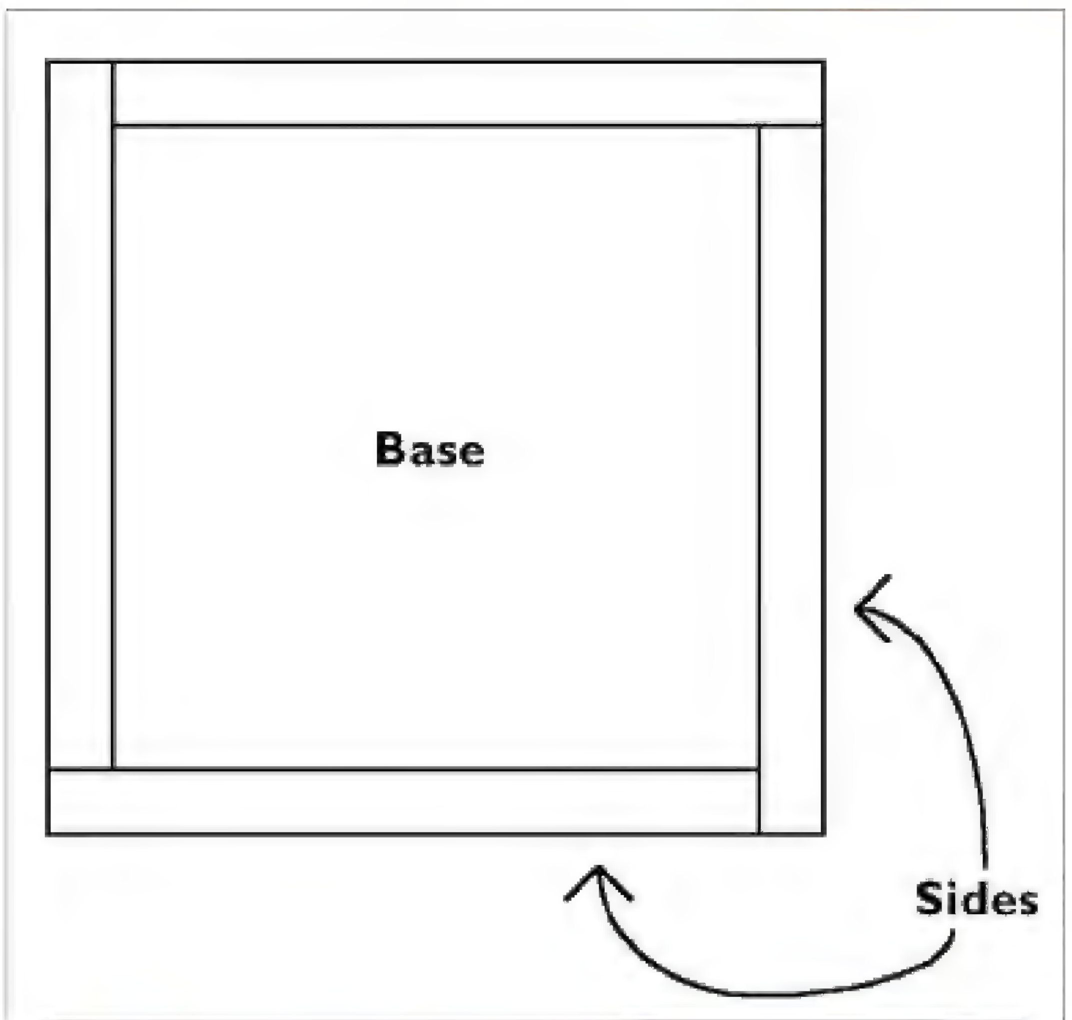


Figure 3. This is the top view of the TTC.

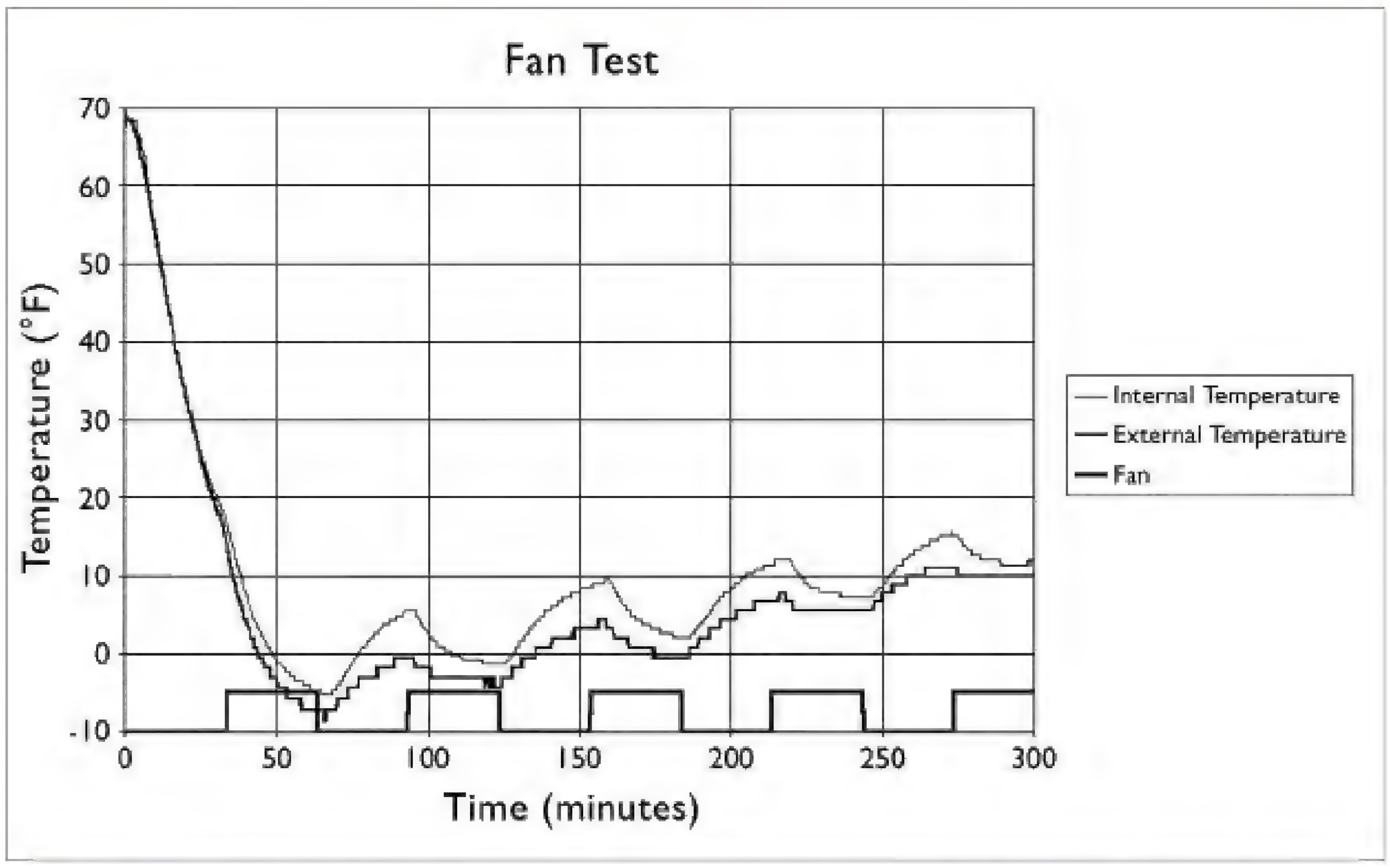


Figure 4. This test shows that overall temperature is affected by air circulation.

is dull. You may notice that Styrofoam cuts better in one direction than another. I get the impression that extruding Styrofoam creates a grain in the sheet.

I cut the two-inch-thick Styrofoam into four 16 by 16-inch squares and two squares measuring 18 by 18 inches. I also cut a half-inch-thick Styrofoam sheet into a 16 by 16-inch square. Select one of the 18-inch squares to be the base and set the other one aside for later (it will be the lid). The four 16 by 16-inch squares are the sides of the TTC.

Fire up the hot-glue gun, as you have some gluing to do. By the way, I find my students are not humored when I hold up a hot-glue gun and say, "Bond, James Bond."

Styrofoam is a good insulator, and I find that hot glue doesn't quickly cool down on it. Moreover, hot glue can get hot enough to melt Styrofoam, so keep the glue gun from getting too hot by unplugging it every once in a while.

Apply glue to the bottom edge of the first side and align it with one corner of the TTC base (as in Figure 3). The side may not want to stay vertical, so work fast and glue two edges of the next side and put it into place. Repeat this with the remaining two TTC sides.

For additional strength, wrap a length of packaging tape around the top edges of the TTC box. The tape puts the top edges under compression and keeps them from splitting apart.

The lid has an inner lip made from the half-inch-thick Styrofoam. First, test fit the lid's inner lip by trying to set it inside the TTC. Be careful you don't damage the inner lip trying to get it in or out of the TTC. I found it was better if I just tried fitting one edge of the inner lip at a time. This way, part of the inner lip

The 2004 Winner of the OnSet Prize

Last year marked a turning point in the amateur radio high altitude ballooning (ARHAB) community when OnSet Computing sponsored a competition for the highest altitude flight in 2004. The competition, called the OnSet Prize, was open to all ARHAB groups. To qualify, flight attempts had to be announced in advance and tracked with GPS over amateur radio.

The winner of the 2004 OnSet Prize is the Treasure Valley Near Space Program (TVNSP). The TVNSP launched their winning flight on the morning of December 27. The 1.1-pound payload was carried on a Kaysam 1,200-gram balloon and in two hours and 26 minutes, reached a peak altitude of 118,946 feet. Their flight beat Bill Brown's previous day's record altitude by only 299 feet!

TVNSP won a four-channel, eight-bit Hobo data logger that measures temperature, relative humidity, light intensity, and one external voltage. Along with the Hobo, they received the professional version of the Boxcar software (Boxcar Pro 4) and an external temperature sensor on six-foot cable.

I'd like to thank OnSet Computer Corporation for sponsoring this competition. You'll find their products used in the NASA Space Grant Consortium's BalloonSat Program. Be sure to check out the OnSet website and see all the great products they offer. You'll find a lot of justifications for launching near space missions with OnSet's computing data loggers.

OnSet Computing
www.onsetcomp.com

Treasure Valley Near Space Project
www.tvnsp.org

remains outside of the TTC while I did the test fit. Trim the inner lip if necessary to get it to fit. Apply hot glue to one face of the half-inch-thick Styrofoam and center it over the lid.

After the glue sets up, test-fit the lid. You may want to do some additional trimming after this fitting.

Now you have an ugly Styrofoam box with a lid.

I added insulation to the TTC by wrapping its interior and exterior with aluminized space blanket material. Cut pieces of the space blankets for the interior of the TTC into squares slightly smaller than the interior dimensions of each side. Use short strips of double-sided tape to hold each sheet of space blanket in place. Then finish the interior by hot gluing thin strips of half-inch Styrofoam onto the inside edges of the TTC box. This way the Styrofoam strips are

Announcing The 2005 Amateur Radio High Altitude Ballooning (ARHAB) Competitions

Last year, OnSet Computing (**http://onsetcomp.com**) sponsored the maximum altitude competition between amateur near space groups. The competition was so popular that this year, there are six different ARHAB Competitions. The 2005 ARHAB Competitions are in these categories:

1. Highest Altitude Reached by a Near Spacecraft

2. Greatest Distance Traveled by a Near Spacecraft (release to touchdown)

3. Longest Mission Duration (release to touchdown)

4. Greatest Distance that Telemetry from a Balloon is Received (for frequencies greater than 50 MHz)

5. Greatest Distance that Telemetry from a Balloon is Received (for frequencies less than 50 MHz)

6. Greatest Distance for Two-Way Radio Contact Through a Near Spacecraft

The ARHAB community is fortunate to have four sponsors for this year's slate of competitions. The following companies are sponsoring the 2005 ARHAB Competitions:

• For Maximum Altitude — *OnSet Computing* and *Amateur Television Quarterly*

• For Greatest Distance Traveled — *Amateur Television Quarterly*

• For Longest Mission Duration — *Kaymont* and *Amateur Television Quarterly*

• For Greatest Telemetry Range (greater than 50 MHz) — *Kaymont* and *Amateur Television Quarterly*

• For Greatest Telemetry Range (less than 50 MHz) — *Kaymont* and *Amateur Television Quarterly*

• For Greatest Radio Contact — *CQ VHF* and *Amateur Television Quarterly*

Please take time to visit the sponsor's websites:

OnSet Computing
www.onsetcomp.com

ATV Quarterly
www.hampubs.com

Kaymont
www.kaymont.com

CQ VHF
www.cq-vhf.com

The ARHAB community is interested in looking for more sponsors. If you are interested in spurring innovation in amateur near space, please consider sponsoring one of this year's competitions.

The rules for the 2005 ARHAB Competitions are pretty simple.

1. The maximum altitude of the near spacecraft is determined by data generated from its onboard GPS receiver (transmitted and/or captured onboard).

2. All distances are measured in great circle distances and will be determined by a GPS receiver or mapping software.

3. Data generated by the onboard GPS receiver is required to determine telemetry ranges.

4. Due to GPS errors, any differences in distance less than one mile, altitudes less than one foot, and times less than one minute are considered ties.

5. The 2005 competitions are open to entrants worldwide.

6. So that ARHAB groups will know to monitor a competition attempt, flights must be announced at least 24 hours before launch to be considered for a record (notify ARHAB on their website).

7. All attempts must comply with applicable regulations, like FAR 101 (a statement of compliance is sufficient).

8. Results from the attempt, including all pertinent data, must be posted on a website ASAP.

9. In order to advance the state of the art, all hardware and software used in an attempt must be open source.

10. To accommodate those flying without a GPS receiver, there is no minimum altitude a flight must reach to be eligible for any record attempt (except for those vying for altitude and telemetry records, which requires an onboard GPS to be valid).

11. Because near spacecraft are occasionally lost, near spacecraft have until the end of 2005 to be recovered. The one exception is when the near spacecraft is proven to be lost in a completely inaccessible area (like the Atlantic Ocean).

12. The rules, decisions, and awards are at the sole discretion of contest officials.

You can track this year's competitions at Ralph Wallio's ARHAB website: **http://users.crosspaths.net/wallio/RECORDS.htm**

To announce an attempt, email Balloon_Sked@yahoogroups.com

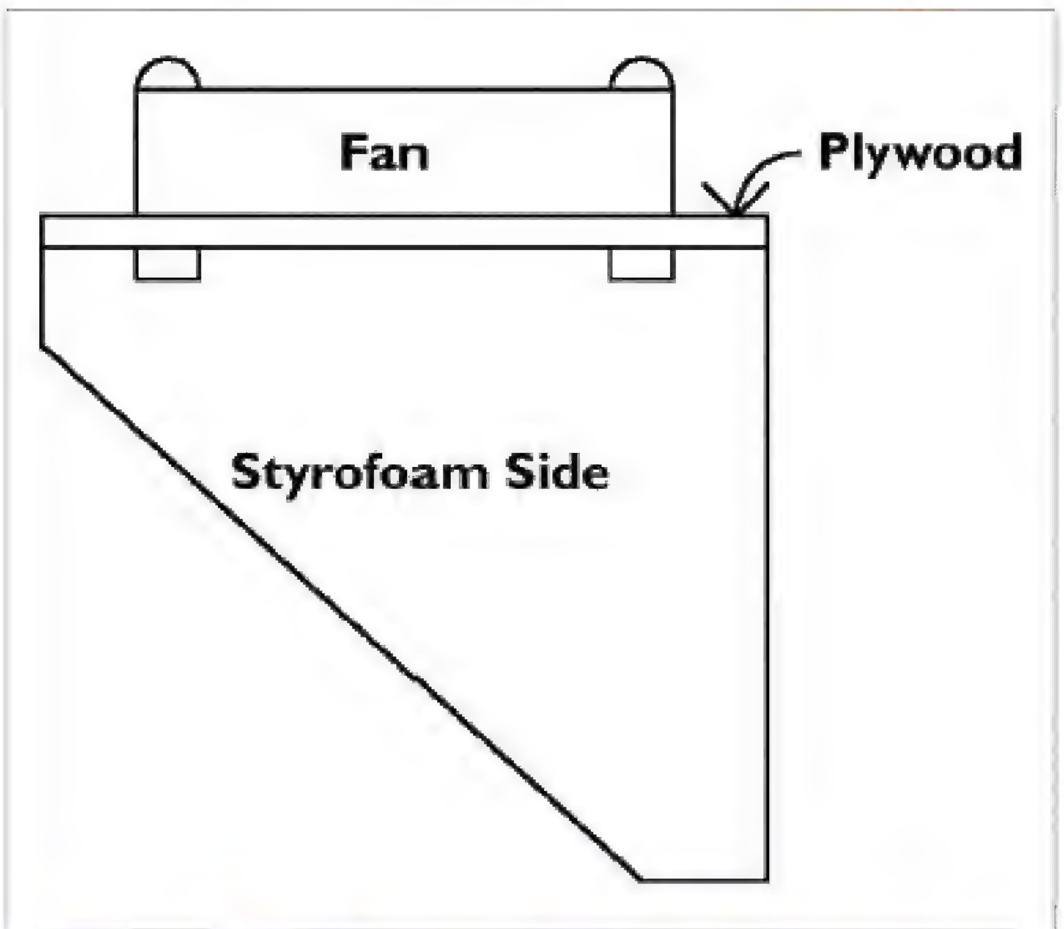


Figure 5. The fan mounting base is shown here.

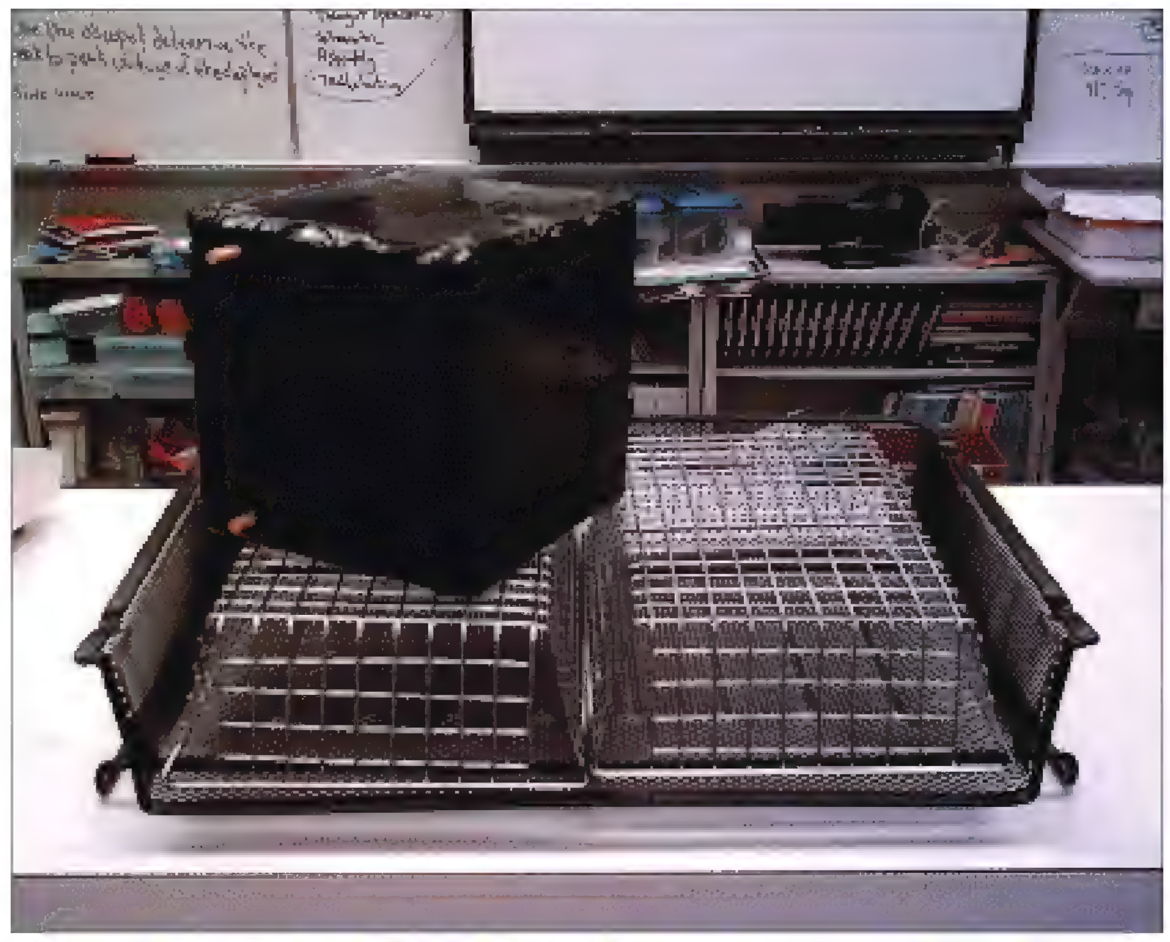


Figure 6. This is how the baskets are placed.

glued to the interior of the TTC and sandwich the edges of the space blanket.

Next, wrap the exterior of the TTC in space blanket material. After wrapping, tape the outside edges and corners of the TTC with aluminum tape to add durability to the space-blanket exterior.

Now, let's do the electrical work.

I used two small CPU fans to circulate cold air inside my TTC. The chart in Figure 4 shows the benefits of using fans. I cycled the fans on and off in 30-minute intervals, and during the test, I measured the temperatures inside and outside of a BalloonSat. You can see that the fans (remember, these are small fans) lowered the temperature by 10 degrees.

First, connect each fan to a battery so you can be sure the fans work before you modify them. The leads on the CPU fans are too short, so you need to extend their length. The fans are mounted to opposite sides inside the TTC, so keep that in mind when you extend the leads. Cover the solder wires with heat-shrink tubing before proceeding.

Cut the 1/8-inch modeling plywood into two squares that are one inch larger than the outside dimensions of the fans. Drill holes in the

plywood so you can bolt the fans to the plywood. Then use the #4 hardware to bolt the fans to the plywood. I only bolted two diagonal corners of each fan to the plywood. Next, cut two supports for each fan out of half-inch Styrofoam. I made mine triangular in shape and clipped the corners. Hot glue the supports to two opposite edges of the wooden fan base.

Locate two opposite sides inside the TTC to mount the fans. Mount the fans high, but not so high that the lid can't shut properly, as there must be some clearance above the fans to circulate air.

To mount my fans, I first trimmed two narrow strips from the space blanket. Then I hot glued the fan supports to the bare Styrofoam in the TTC sides and sandwiched the raw edges of the cut space blanket.

Drill a small hole in the wall of the TTC near the top, as the wires from the fans will exit this hole. To prevent the space blanket from ripping at the hole, cover the hole with a small square of aluminum tape. Pass the wires of each fan through the exit hole you drilled in the walls of the TTC. Use tape to immobilize the wires of each fan against the interior walls of the TTC.

Now seal the exit hole with hot glue on the inside and outside of the TTC.

Slide the jacket of the power plug over the fan wires. Then solder the ends of the wires together and to the tabs of the power plug. I like to put a drop of hot glue over the soldered tabs of the power plug to make sure the interior of the power plug is well insulated. Slide the jacket of the power plug back over the soldered tabs and screw it closed. Change the power plug on your wall-wart power supply to match the fans' power plug. When you're done, plug in the wall-wart and apply power to the fans.

They should spin up and begin moving air. I can't verify this, but I suspect that the larger the fans, the

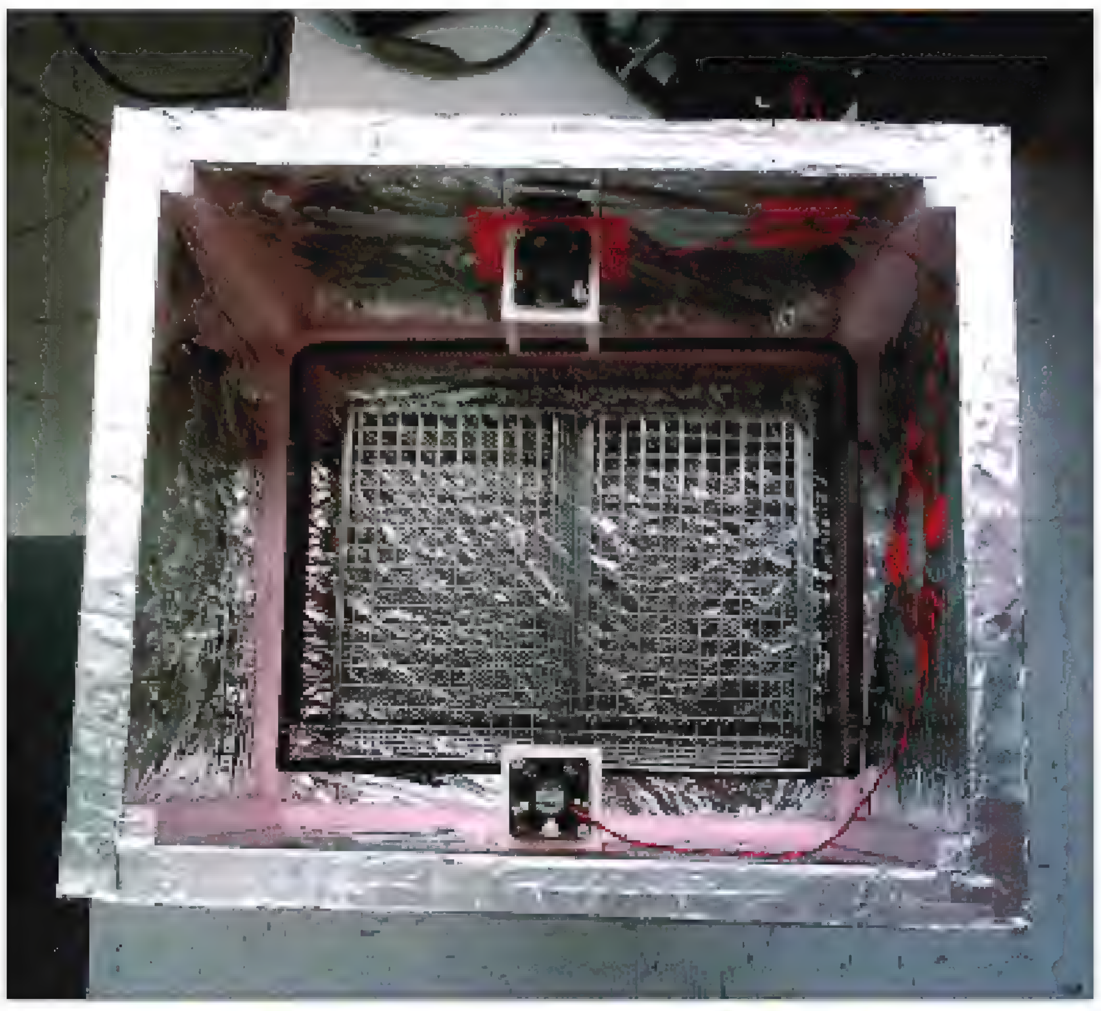


Figure 7. Inside the thermal chamber.

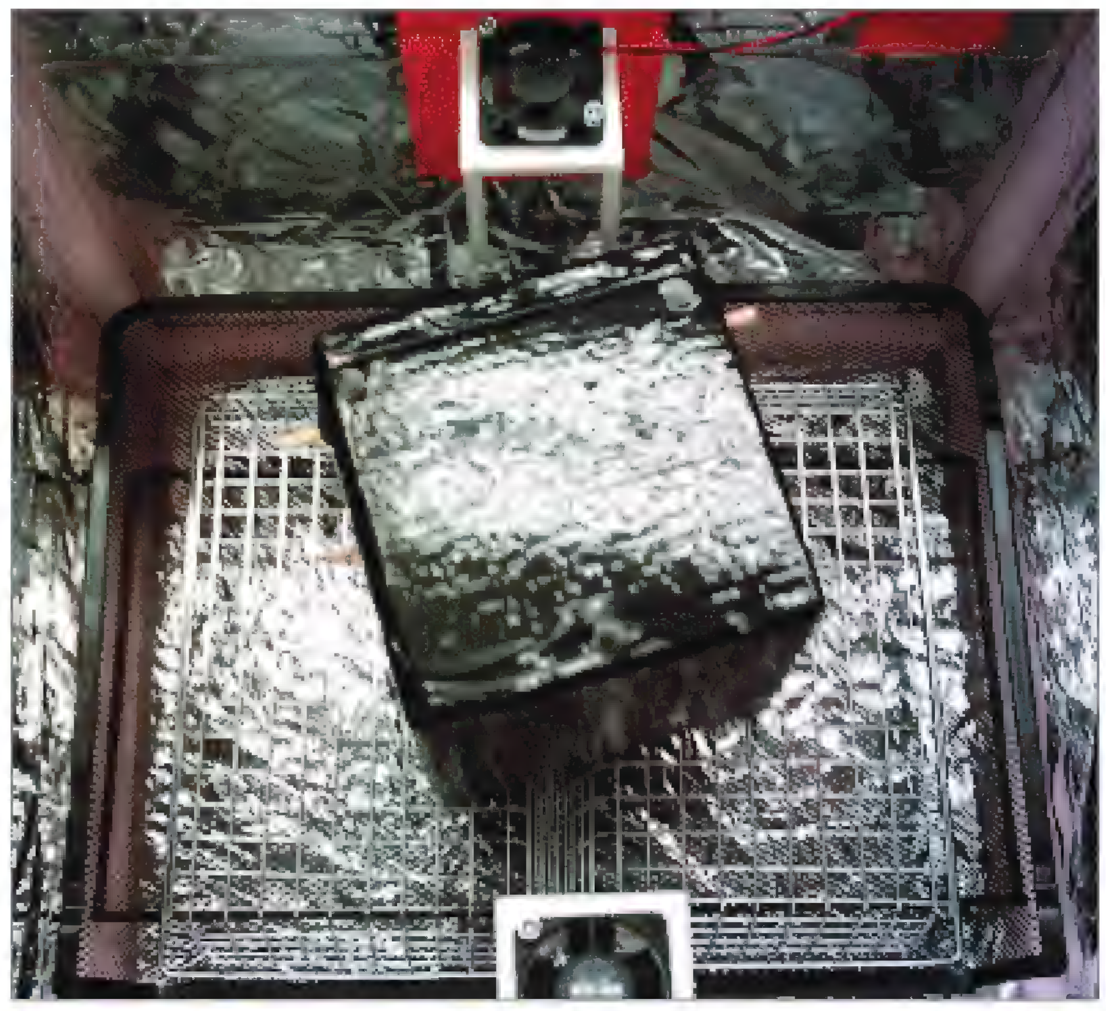


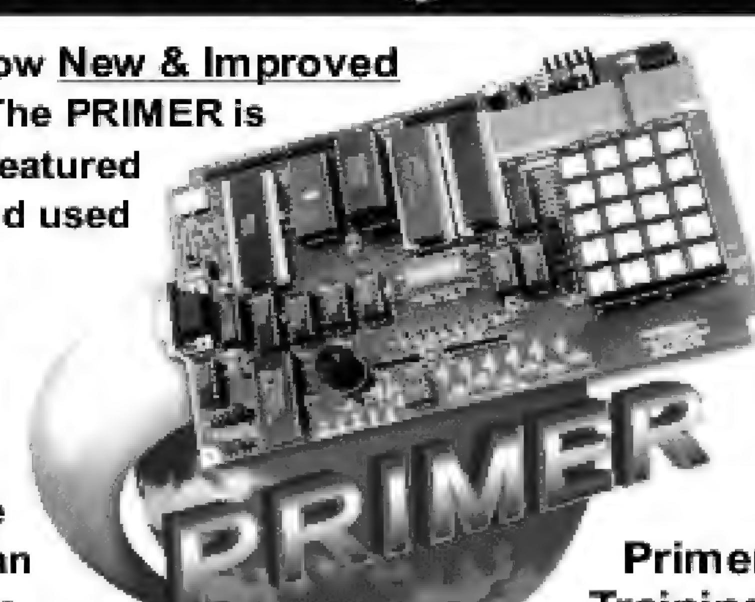
Figure 8. One of my BalloonSats undergoing testing.

cooler the interior of the TTC (unless the fans are so large they generate lots of heat).

To assemble the dry ice chamber, I used two desktop metal mesh letter baskets and one wire mesh "in" basket. The larger "in" basket holds two chunks of dry ice, and the two smaller letter baskets cover them. The open-mesh design allows air to circulate freely around the dry ice while keeping the device undergoing testing and the space blanket inside the TTC from making direct contact with the dry ice.

Using the TTC

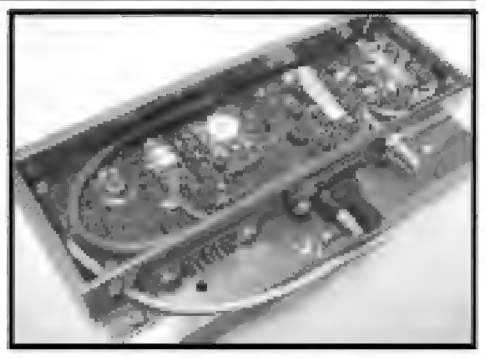
First, you need to get a victim to test. Purchase about a pound of dry ice and break it into two or more pieces. Use gloves when handling dry ice, as getting frostbite is not a good source of entertainment. Put the "in" basket into the TTC and place the two chunks of dry ice onto it. Place the letter baskets over the dry ice and then place the item to test on top of the upside down letter baskets. Close the lid and let the TTC sit. Temperatures inside the TTC will drop to below zero within 30 minutes. **NV**



Windsor

See more surplus electronic goodies at: www.shopatwindsor.com

25 Watt UHF RF Power Amp

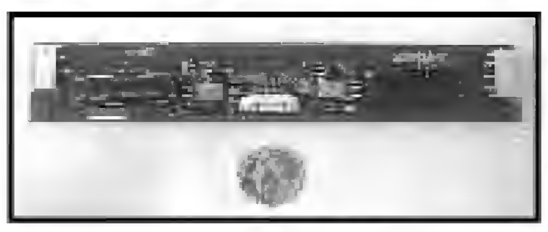


New, heavy duty UHF power amp assembly. 10 mW in for 25 W out! Commercial quality with built in PIN antenna switch and low pass fil ter. Tuned for 550MHz, add 5 parts (included) for 440 MHz Ham band. On big 1" thick 3 lb aluminum heat spreader!!
0133086R $49.95

Electroluminescent Light Panel

Electroluminescent light panel as used in LCD backlights, runs on 75 140 VAC. Soft green glow, ideal for nite lights or fancy light ing projects, runs great on regu lar AC line voltage. Size 2.75" x 1.25" and just a few hairs thick! Super neat great project item!!
0133512R Bag of 25 pcs!.........................$5.95

CCFL Florescent Light Inverter

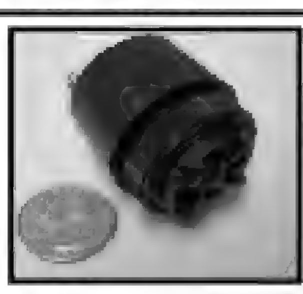


New power inverter drives 2 lamps up to 5W each! Simple to use, 12 VDC in, con nect florescent lamps to output. Module gen erates correct starting and operating voltage, lamp current and is even dimmable!
0128520R $9.95

Laser Scanner Bar Code Module

Wow! What a a cool item! Brand new laser scanner module (size 1x1x1.5"!) includes red laser, beam splitting mirror, opamps, photo sensor, transistors, processor, ICs, etc. From handheld laser barcode reader. We sold out of the last style we had! No specs, but buyers figured out the hook up for the last group, we'll post on the web any new info on this one, should be easy, has just 12 pins on the connector. Styles may vary.
0131346R $14.95

Piezoelectric Alarm



WOW, is this thing LOUD! Runs on 2 12 VDC and draws mere milliamps, 103db output! Rotat ing bezel allow easy volume con trol too! 1.25" dia and 1.5" long. Google for specs: Bell Audioalarm XC V09 212 S
0132165R $4.95

Watch Camera Button Battery

Popular watch/photo battery at a dynamite price! Brand new Eveready EPX76/SR44 same size as LR44/AG13 as used in laser pointers, toys etc but Silver Oxide with better life and specs at the store, these go for over $2 each!!
0133087R Big tray of 100 pcs!!.................$9.95

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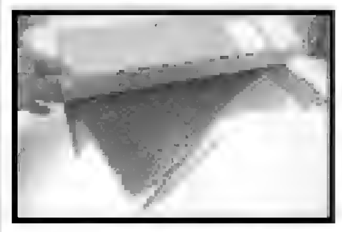
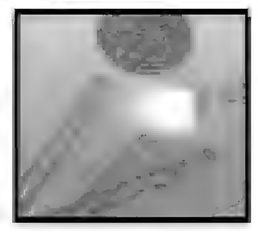
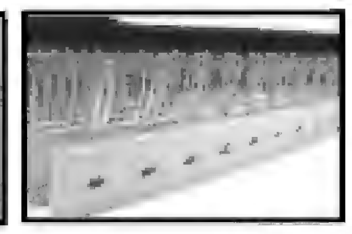
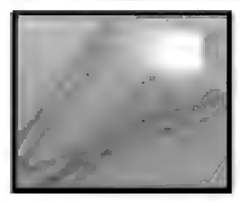
LED BLOWOUT !!!

Here's a deal that just will not last long Wind sor's LED Blowout! Super high quality, factory prime bright LEDs. Ideal for all those projects that you've wanted to build, but just didn't have the quantity of LEDs needed. You will not find pricing like this ever again we bought out two factory inventories! Here's the scoop: Big bag o leds have 500 pcs and are all RED jumbo 5 mm size with crystal clear bulbs. You pick the lumi nous intensity, bear in mind that the 2500 mcd high bright units are flashlight intense! Big buy ers will love the 2,000 LED boxes! These LEDs are the smaller T 1 size with full leads, available in Red or Green. Imagine 2,000 Leds for less than a penny each!

0131288R High Bright	500pc bag	$19.95
0131292R Standard Bright	500 pc bag	$14.95
0130956R Box o leds Red	2,000pcs	$19.95
0130955R Box o leds Green	2,000pcs	$19.95

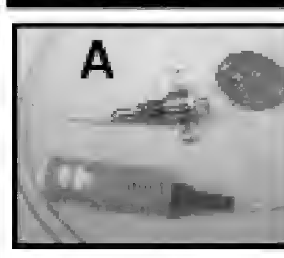
Windsor's Blue LED Special

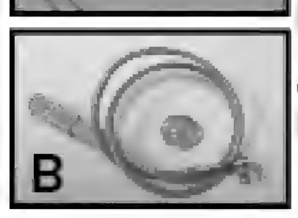


Holy Smokes! Can you believe the price on this BLUE LEDs? First quality from our factory buyout. Big and bright! These normally sell for $1.50 each and that's in big quanti ties! We're crazy to sell 'em so cheap!!

0131297R	50pcs	$19.95
0131297	500pcs	$99.95

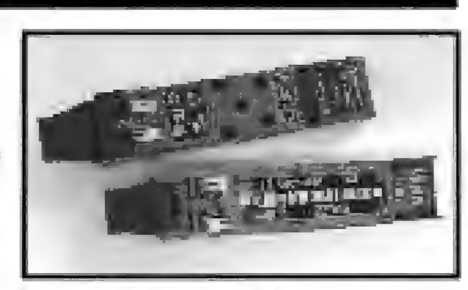
Laser Fiber Optic Transmitter





Brand new HP Agilent model LST2829 Laser transmitter mod ule. Capable of 622 MB/s data rates, 1 mW output power, 1300 nm wavelength, includes on chip power monitor diode. These are high end quality lasers and not often found on the surplus mar ket! Two style available, A: 32" long thin pigtail fiber and B: 16" long encased fiber. Each has the same electrical specs. Price: $9.95 each
Item A: 0128526R Item B: 0128536R

Laser Fiber Optic Transceiver



New, by Infineon. Has laser transmitter and receiver in one package! 1.25 Gb/s data rate up to 700 M on low cost multi mode fiber! Super small size, complete specs on the web. Make your own fiber optic link!
0125461R (Set of two) $19.95

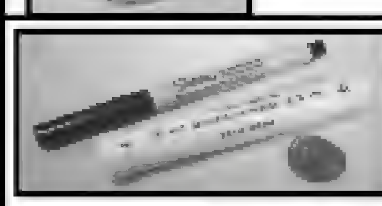
Tiny Beeper Speaker

Star PMX 04B beeper speaker as used in cell phones and pagers. Only 1/2" dia, easily drive from micro or single tran sistor driver circuit included!
0133088R Group of 5 pcs $2.00

C size Nicad Battery

This is the real deal, a true 2 A Hr Nicad, Button top works in any device too! Brand new by Sanyo.
0130380R $2.00

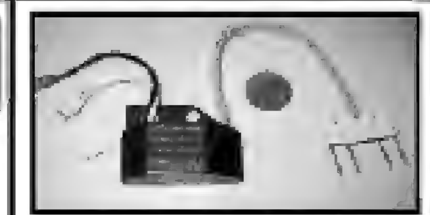
Nicad Battery Stick



New 4.8 V 500 maH Nicad battery. 0133511R.....$4.00

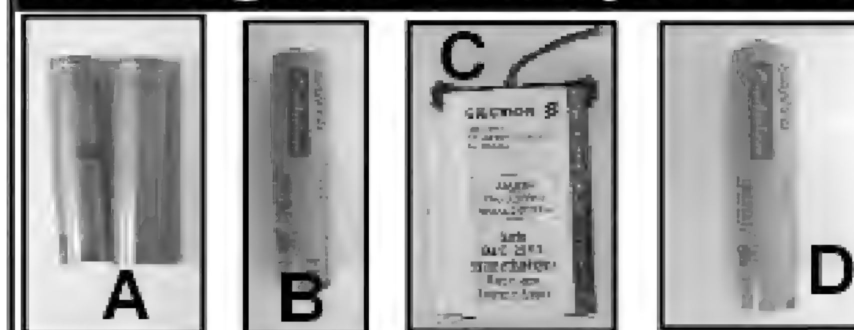
www.shopatwindsor.com

Ion Generator



Its super easy to build your own Ion Breeze air purifier! New module, 120 VAC in, 7.5KV out! Surplus from air cleaner maker who sold them for $200!
0128873R $7.95

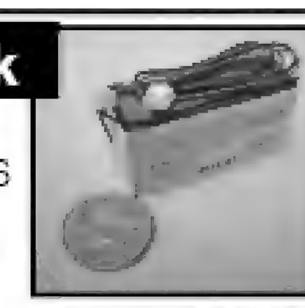
Rechargeable Battery Blowout!



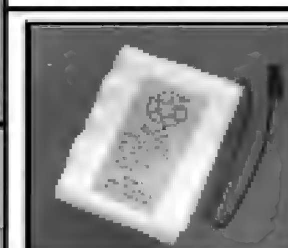
Popular Nicad batteries, 1.25V All brand new. A, B, D are NiCad, C is NiMH. A has no sleeve.

A: AAA 400mah	0125339R	2 for $1.00
B: AAA 250 mah	0133089R	5 for $3.00
C: 3.6 Volts 750mah	0125348R	2 for $3.00
D: AA 700mah	0132163R	5 for $3.00

Nicad Battery Pack



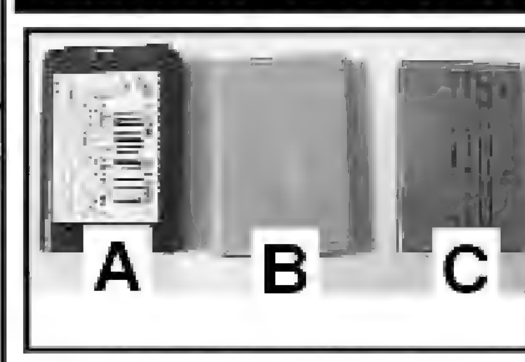
Brand new high power densi ty rechargable battery pack. 6 volts, 650 maHr. Space sav ing rectangular shape approx 2x1x0.75" with 6" wire leads.
0132161R $4.95



Nice, new 5 AA cell nicad pack. 6 Volt 700mah with 6" wire leads. Great for projects or cordless phone replace ments.
0125345R......................$2.50

Big box of 50 brand new AA button top NiCads. Fit anywhere an AA battery does. 1.25V 800mah. Best price in the USA!
0128870R.............$19.95

Lithium Ion Rechargeables !!



Rechargeable Lithium batteries pack the highest density of power for size and weight! Ideal rec tangular size is easy to fit in your project. All 3.6 Volt and approx rated Amp Hour capacity.

A: 1Ah 1.95x1.34x.4"	0125337R.....$1.50	
B: .8Ah 1.95x.1.34x.25"	0125349R.....$1.25	
C: .8Ah 1.95x1.24x.23"	0125350R.....$1.25	

Truck Stereo

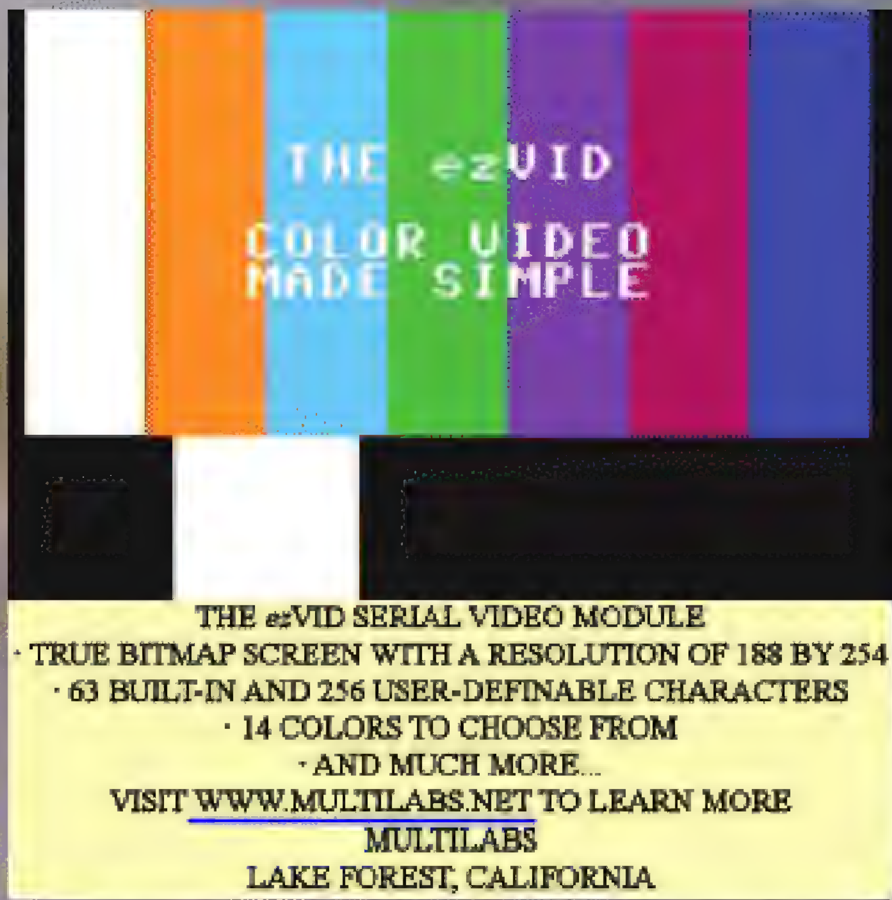
New in dash cassette stereo AM/FM radio, LCD display, drives 4 speakers (80 watts!) Even has Weather band! Quality fully enclosed case, easy hookup, great for in wall home installations! Runs on 12 VDC.
0128872R...$29.95

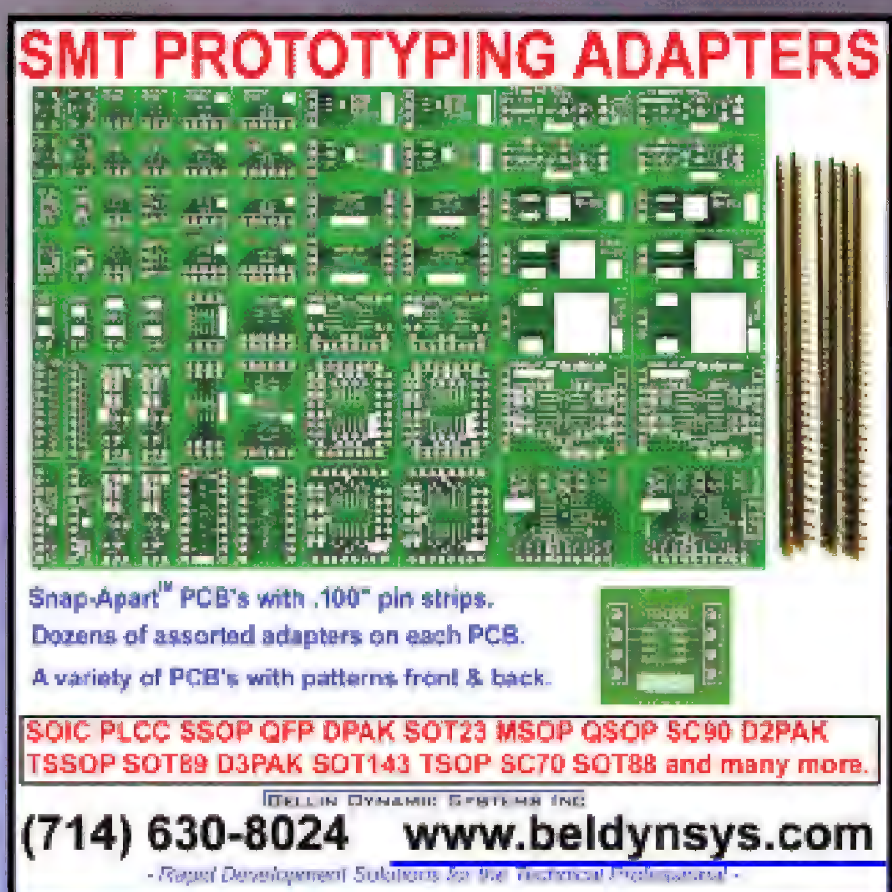
Handy Tool Set

Well made quality 3 piece plier set. Includes deluxe padded zipper case. Pliers are big 8" in size, you get: needlenose, diagonal and lineman style with handy crimper and stripper dies on each tool! Get a few for the car, gifts and toolbox, they are that nice!

0128871R $12.95

Circle #29 on the Reader Service Card.





Electronics Showcase

Reader Feedback

Continued from Page 6

Dear Nuts & Volts:

I used to be a subscriber of *Poptronics*. When it ceased publication, my subscription was transferred to *Nuts & Volts*. I enjoy many of the articles in *Nuts & Volts*, although I am not interested in robotics per se. One thing that I find unfortunate is that there appears to be a degree of sloppiness or thoughtlessness or just a plain lack of knowledge about the use of the English language on the part of either some of your writers or editors.

For example, the use of adjectives instead of adverbs to denote action. On occasion, one has to guess at what the writer intends. Sometimes this is obvious but at other times — especially for a person whose first language is not English — the result can be assumptions on the part of the reader which are at least incorrect. When we present a thought or concept to another person, in person, we can sense if that person understands and we can clarify things on the spot if there is any doubt. When we write an article, we do not have the luxury of this kind of feedback so we must be careful to use language correctly to present clearly and accurately the message we intend.

Misuse of terminology is another concern. The world of electronics is based on generally well-defined terms to describe parameters. When these terms are used improperly, it can lead to confusion and even unintended misinformation.

One example is the term "baud." This is often used instead of the term "bits per second." Yet, the two are very different concepts and only equal numerically in special circumstances. Again the term "baud rate" is often used when, in reality, any pulsing system with a "baud rate" of other than zero is an unstable system!

Another such misuse of terminology is the confusion between "speed" and "rate." Speed is a special case of rate, implying velocity, e.g., how rapidly something moves from one place to another in terms of miles per hour, feet per second, etc. (not pulses per second!). I would suggest that a little more attention to these details would remove some of the confusion.

Ernest J. Moore, P. Eng. (Ret)
via Internet

Dear Nuts & Volts:

I just read the "Scrounging For Parts" article in the April 05 issue of *Nuts & Volts* and a comment came to mind which I'm sure others have pointed out by now. If you drop a CRT you will not "release a pressure of 2,000 plus psi." CRT's aren't pressurized to 2,000 PSI, in fact they're not pressurized at all! They're a vacuum, so by definition, the outside is under a pressure of approximately 14.7 PSI, enough to cause a violent implosion and subsequent explosion as the glass fragments continue their path but nowhere remotely near 2,000 PSI.

I would also suggest — contrary to another warning in the article — that people *do* power up items (after a visual inspection inside) to find out what's wrong with it. Many times, it's a simple problem which can be repaired by scavenging parts elsewhere.

James Sweet
via Internet

Dear Nuts & Volts:

The March 05 article "Start Your Own Casino" was a good "Intro to PICs" article for beginners. Unfortunately, it was based on a PIC that's way past its prime.

Pointing beginners to EPROM or OTP ROM adds complexity and cost. There are plenty of Flash memory 16F or 18F parts that could have been used.

Nuts & Volts has vacuum tube articles but not because they are easier to work with than transistors. Please don't reject articles based on antiquated components, but see if you can steer the authors tocurrent components.

Chuck C
via Internet

The Business of Electronics Through Practical Design and Lessons Learned

In The Trenches

Teaching and Training

Because engineers create new things and new ideas, other people have to be instructed in how these new things and ideas work. Naturally, it falls on the engineer to do the teaching and training. Understanding what is necessary and expected of you when you talk to a group of people can be helpful.

Teaching versus Training

You've just finished your state-of-the-art meat analyzer for mad-cow disease. Using breakthrough nano-technology, your new device can detect those pernicious prions in the spinal fluid of cows. You're really excited to get into the next stage and do a design for human detection, when your boss calls you into his office. Your new assignments: 1) train operators to use the machine, 2) teach technicians how to service and repair the analyzer, and 3) work with marketing to educate potential customers about the breakthrough design. This isn't what you were hoping for, but realistically, you're the best person for the job.

The first thing is to realize that there is a big difference between training and teaching. You train a dog to roll over but you teach a child to speak. Fundamentally, training is completely addressing a topic with responses that are usually fixed. There is little or no thought required for these responses. It's just "when this happens — do that." People are trained to operate machines, use software, ride a bicycle, and so forth. Training changes how you perform.

Teaching is providing the conceptual tools needed to address a field that is unrestricted. For example, engineering is an unrestricted field. No one can know everything about engineering. While you can memorize lots of formulas, you will need to know when and where each formula should be applied, and there is no way to memorize all these situations. So you must learn to analyze the situation and choose the proper formula. Teaching changes how you think.

Naturally, teaching and training are not mutually exclusive. In fact, training and teaching occur simultaneously in many instances, although some fields require more training than others. Doctors need to match symptoms to diseases. There is a lot of memorization in medicine, because there is a limited number of diseases and people are pretty much the same.

Engineering, however, is one of those fields where teaching plays a much larger role than training. Your new analyzer falls into the category of bio-engineering. This means that you'll be interacting with some people who are used to being trained (doctors) and other people who are used to being taught (technicians). Realizing this difference beforehand can be critical.

Training

Remember that training is related to performance. So, instructing people in how to operate your analyzer will be mostly rote learning. "You press this button to start the analyzer, and the results come out here." Of course, this doesn't mean that everything you teach must be training. It's certainly useful for the operator to have a fundamental understanding of what your

machine does and how it does it. Additionally, understanding the results may require thoughtful consideration rather than just following certain rules.

There are two additional important points here. The first is that training fosters rule-bound behavior. Is this what you want? If not, then you should teach rather than train. The second point is the idea of "need to know." What do your users really need to know in order to operate your analyzer properly? This defines your training program, so include everything they need to know and exclude everything else.

Training materials are necessary, and they are often fairly complex documents. Unfortunately, these materials can be poorly written and organized, and they rarely indicate what is important and what isn't. A classic example of this is the "FORMAT" command in the original Microsoft MS-DOS operating system. It would completely wipe out the hard drive without any warning (later versions fixed this).

Good training materials provide examples and show how to do something rather than what something does. For example, suppose you want to copy a file, so you look up "copy." Getting, "Copy is a command that allows you to copy files," is useless for you. You already know what copy is. You need to know how to properly implement the copy command. Providing an easily accessed summary of important procedures with clear examples is critically important in producing useful training materials.

Teaching

When you teach, you try to convey fundamental ideas that can be used. This is usually harder than training because there is less structure. Teaching is open-ended. How much of what topics will be best? Getting people to think is rarely easy. Remember high school and college: "Just tell us what's going to be on the test."

Learning concepts that you must understand enough to apply takes effort. But learning and understanding concepts is incomparably more valuable than training. This is because concepts can be applied in unlimited ways, where training is restricted to special situations. You can apply engineering concepts to biology and chemistry and create a machine that can detect mad-cow disease. You could never do that if all you did was memorize engineering formulas.

A subtle but important point is that one of your students may apply a concept in a way you never considered. This can result in a question you cannot answer or a brand new idea. It is extremely important to recognize when this happens and foster it. This is a success! You have a student who is thinking. This is exactly what you want. Unfortunately, human nature is in conflict, as you may feel embarrassed or slighted and want to rebuke the student.

After all, you're the person standing in front of people and you should know all this. It's natural to feel uncomfortable, but it's vital to overcome this feeling and encourage the student. No one can know every concept and application. Not even the teacher. Besides, always remember that a student may actually be smarter than you.

Basic Errors

The two basic errors are teaching rather than training and training instead of teaching. Let's look at a couple of examples.

Suppose you're training secretaries on how to use a new word processing program's sorting feature. There is no reason to teach, in detail, all the various types of sorting algorithms. How a bucket sort differs from a bubble sort, how you created a combined sorting procedure that is more efficient for variable length records, and so forth, and so on, ad infinitum. It seems obviously wrong when it's stated here. However, we've all experienced people doing this.

The term I've heard is "Geek-Teach," and, truthfully, this is a common mistake that many engineers and technical instructors make. As noted previously, this is an example of failing the "need to know" require-

ment. These secretaries only have to know how to use the sorting feature. They don't have to understand it.

A more devastating error is training instead of teaching. This is especially true when powerful forces are being controlled, such as in a nuclear power plant. Let's do a thought experiment.

You have a closed jar with a tube running out of the bottom into a hollow rubber ball. You fill the ball, the tube, and half the jar with water. If you squeeze the ball, the system pressure increases and water flows into the jar, increasing its water level. There is a direct relationship between pressure and water level. It's a simple concept.

Except, if you train people that higher pressure equals higher water level, they don't understand the concept. They only remember the relationship. Most of the time, that's not important. It does become important when a failure occurs. This happened at Three Mile Island Nuclear Power Plant on March 28, 1979.

In this instance, an electromatic pressure-relief valve stuck open, while its indicator light showed closed. This allowed air (steam actually) out of the top of the jar (pressurizer loop). Instead of a closed system, the system was open, and the result was that the pressure decreased and the water level increased.

This was a relationship exactly the opposite of what the operators were trained to believe. They had a dilemma. If they believed the coolant pressure was too low, they should increase the pressure by increasing the coolant pumping speed. If they thought the water level was too high, then the proper action would be to cut the coolant pumps. But, which indicators were right and which were wrong? Because they were not taught the simple hydraulic principles of open and closed systems, it was impossible for them to make sense of the conflicting measurements.

Meltdowns happen.

Tests

Part of any training or teaching program is determining how successful the instructor is. This is accomplished by testing the students, and with training, the questions are pretty easy to create. All that you need to do is have the students repeat what was presented. Multiple choice questions are common and appropriate.

But, for teaching, how do you test how the student thinks (rather than what he remembers)? Multiple choice questions are not as good a choice. The dreaded essay questions are more appropriate, because the teacher can follow the student's logic and reasoning. Even if the student makes a simple math error, the text may show that he fully understands the concepts that were taught and is applying them correctly. But essay

tests are hard to grade and are subjective. So, multiple choice questions are used nearly exclusively for all testing. If you are creating "teaching" questions, try to force the student to apply a principle in order to get the right answer. Don't have him just repeat something — that's training.

Multiple Intelligence

The rest of the column will concentrate on teaching because it's a much more difficult task. There are many approaches to teaching, and some are better than others. Some people are more suited to certain teaching styles than others. Individual students respond differently to various styles, and there is no single best method of teaching. But, clearly, some methods are better than others. (Reading your notes to the class in a monotone voice is not a good technique.)

These differences have been studied and classified fairly recently by Dr. Howard Gardner. He has proposed the concept of "Multiple Intelligence" (*Frames of Mind: The Theory of Multiple Intelligence*, Basic Books, 1993).

The basic idea isn't really new. It's simply that different people learn in different ways. Some people learn best by doing, while others learn best by watching. What Gardner did was to identify and document eight specific methods of learning that are related to actual brain functions and structures. These are: Music Smart, People Smart, Picture Smart, Body Smart, Self Smart, Number Smart, Word Smart, and Nature Smart.

All people have all of these capabilities. But most people tend to focus their "intelligence" into two or three of the methods. Engineers tend to be Number Smart. They like math and logic and enjoy solving problems. Additionally, engineers tend to be Self Smart. They often prefer to work alone and at their own pace. But, right now, stop for a moment and recite your "ABCs." You'll most likely end up with that kid's tune running through your head. That's Music Smart.

This means that the more varied your teaching style, the greater overall success you will have. Additionally, if you have a specific audience, you can tailor your approach so that it will match their learning abilities.

Teaching Methods

The most common teaching method is a lecture. But according to the National Training Laboratories, it's the least effective in terms of "retention." Typically, there's only a five percent retention rate for a lecture presentation (it's zero if you fall asleep). Reading the material gives 10 percent retention; audio-visual is 20 percent; a demonstration yields 30 percent; a discussion group (also called the Socratic Method) gives 50 percent; actually performing the concepts (as in laboratory exercises) results in 75 percent retention; and when you teach others, you remember 90 percent.

Again, the basic reason that the lecture is the most common method of teaching is because it's the easiest. You just stand up and start talking. If the class is 150 college freshmen, it's probably impractical to break them up into discussion groups. Making demonstrations large enough for such a large class is also difficult.

It's unlikely that you'll be teaching such a big group. You'll probably have 10 to 15 students. This means that most of these methods are possible and practical. You should try to employ them.

Concept Formation and Detail Retention

If you understand the concepts, the details often become self-evident. This means that you can forget the details because you can derive them whenever you need to. Instead of cluttering your brain with facts and fig-

ures, all you have to do is understand, which is a lot easier said than done.

Let's see how this works by designing a nuclear reactor's core.

We know that a critical mass of radioactive material generates lots of heat. If we have a sphere of material, we won't be able to withdraw heat from it very well because the surface area-to-volume ratio is small. It's clear that we need a large surface area to volume. A thin rod is much better. (A ribbon is better still, but it's harder to manufacture and creates an asymmetrical critical mass. Let's keep it simple.)

We want the rods to be small enough in diameter so that the heat differential from core to face is small. We want to extract the most heat as possible. Since we know metals have fairly good thermal conductivity, we can estimate that the diameter of these rods should be less than an inch. Let's make them 0.5 inch in diameter.

In order to create a critical mass, we'll have to have lots of these rods close together. Obviously, we have to extract the heat to use that energy and cool the core. Since we're talking about megawatts, we know that the cooling system will have to be huge.

Additionally, there's a problem. Uranium has poor mechanical and chemical properties. We'll have to encase the rods with something better, but this will thermally insulate the uranium from the coolant. So there's a trade-off: We want it thin for better thermal properties and we want it thick for better mechanical properties.

The point of the exercise is to show that the details become clear if the basic concepts are understood and applied properly. You don't have to remember the thermal conductivity of uranium to get a general idea of how thick the rods should be. (Of course, in a real situation, you would reference the proper formulas to optimize the design.) It's much easier and quicker to manipulate concepts than it is to arrange a myriad of details into a pattern. This is also called "top-down design." It becomes clear that teaching concepts, rather than details, is much more useful.

Teaching Tools and Tips

If you are tapped to do some teaching, it's a good idea to buy one of the many books on the subject. But, realistically, you probably won't. So, here are a few pointers that may help:

During a lecture, don't read. Your notes should only identify which topics you need to discuss. Conversational speech is much better than reading.

Don't stand in one place. Moving around requires the students to follow and keeps them focused on you (besides a moving target is harder to hit with a spitball).

Be excited about what you are teaching. If you're not, how can you expect your students to be? Ask the

class questions and foster discussion. Use the other teaching methods described above, if possible.

There is always room for humor in teaching, but be sure to keep it clean. You can get into serious trouble for inappropriate comments. Like a spice, humor should only add sparkle and interest to your presentation; it shouldn't overwhelm it. Self-depreciating humor is often effective. You might as well laugh at yourself; after all, everyone else does.

I find analogies very useful. They create a concept relationship that's easy for many people to understand. But it's important that the analogy be obvious and appropriate. If it's not, it only becomes confusing.

Examples and asides (or digressions) can be effective. This is because they're more like stories. People like listening to stories. The apparent change in the discussion topic reduces boredom and, what I call, "saturation." People can only concentrate for so long, then they tune out. They've become saturated. Telling a "story" helps counteract this.

Use a multiple intelligence approach. Use props. If you're going to discuss sorting, bring in a deck of cards and sort it. Use rhyme to make important points. "If the glove doesn't fit, you must acquit." You remembered where that came from, didn't you?

There are an unlimited number of ways to present your topic. Be creative. Yes, it's hard and it takes work. But, like most things, doing it well takes effort.

Another very powerful teaching tool is drama. Who can forget those dramatic driver's ed movies in high school. Or the: "This is your brain. This is your brain on drugs," public service announcement. For your mad-cow disease detector you might want to show pictures or video clips of sick animals or, perhaps, their sponge-like brains. Gross but effective. Don't forget that being effective is *the* critical factor in teaching.

Teaching Makes You Think

As we noted above, teaching changes how you think. This cannot happen by accident. As a student, you must think about what is being presented and incorporate that into your mental world. What's more, you must want to do so. Your world is round or flat depending on what you choose to believe. Your beliefs are shaped by what you know, experience, and learn. The bulk of this knowledge, experience, and learning comes directly from your teachers (be they parents, friends, or instructors).

As a teacher, it is important to realize that your job is to shape the world of the student. It's a big job. And, hopefully, you'll shape it in a way that's useful and valuable for the student. **NV**

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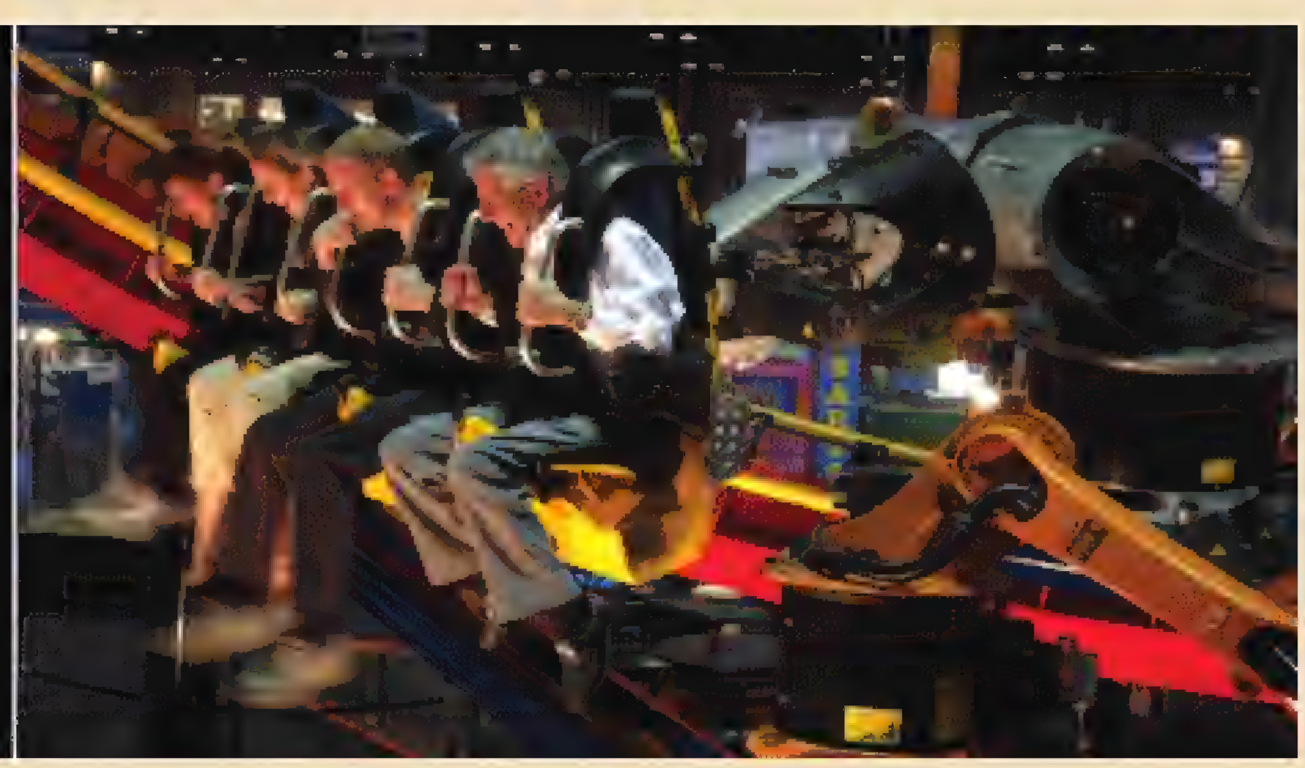

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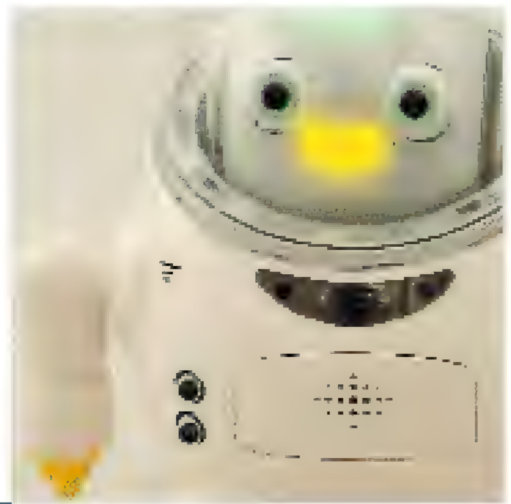

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#05051 **Emil via Internet**

I play drums in a rock band. I would like to develop a hollow drum stick with electronics and fiber optic lights leading up the stick tip that will change color from blue to green and then from red to white based on the increasing frequency of the drum stick hitting the drum head. This circuit may encompass a small microphone (or impact switch), frequency to voltage converter, and proper logic to turn on each LED at a set drum beat. Does such a chip arrangement exist to design this circuit into a small package? The effect onstage should be very interesting for the audience, as the drum sticks appear to generate fire with increasing hand speed.

#05052 **Brian Andresen Livermore, CA**

I was wondering how well an FFT algorithm can represent an audio signal. For example, if you have 256 real basis frequencies to convert an audio signal to an FFT frequency spectrum and converted it back using the same basis frequencies, what would your audio quality be, in terms of THD? I thought you could get a better result if you used pairs of real and imaginary basis frequencies, but this might be equivalent to using twice as many real basis frequencies.

Is there a simple relationship between the number of basis frequencies and THD (audio>FFT>audio)? Given the currently available DSP technology, this should not be a problem. If you could get an acceptable signal back after this transformation, it would be an interesting way to transform audio signals and could possibly be useful for RF, etc.

#05053 **Exidor via Internet**

I need an inexpensive I/O card that has about 12 digital input/outputs and six analog input points. It needs to fit into a standard slot in a PC. I don't need high speed sampling or anything else too fancy. Can someone recommend a card?

#05054 **Warren Bowman via Internet**

I was troubleshooting a Tektronix scope's high voltage circuit and I happened to break a germanium diode. It looks like it functions as a switch in this application. Can someone explain why a germanium diode would be used in any circuit other than a crystal radio? I know it has a lower forward voltage than a silicon diode and a much lower current rating. Are they sometimes used as fusing devices because of this lower rating?

The diode only has a Tektronix part number and I'm wondering if any germanium diode would work. Thanks! I think your magazine is great!

#05055 **Richard via Internet**

I would like circuit suggestions for measurement of the dark (Townsend)

This is a READER-TO-READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

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ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by email or we can not send payment.
- Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

To be considered

All questions should relate to one or more of the following:

1) Circuit Design
2) Electronic Theory
3) Problem Solving
4) Other Similar Topics

Information/Restrictions

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

Helpful Hints

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.

current in a neon bulb. I would like to use a Keithley 181 nanovoltmeter to take measurements up to six figures. I know I am using a voltmeter to measure current, but I want to get the benefits of the sensitivity and accuracy of this particular instrument. The ultimate reason for doing this is to detect radiation from biosources.

#05056 **Gary Grinnell**
via Internet

ANSWERS

[#2055 - February 2005]

I have a bunch of unmarked LEDs (light emitting diodes). Is there any way to determine the specs (forward voltage) of an LED if you don't already know it?

All Electronics (**www.allelectronics.com**) has an LED tester — stock #LT-100 — which is powered by a nine-volt battery. A similar tester — stock #14371-TE — is sold by Marlin P. Jones and Associates (**www.mpja.com**). You can plug an LED into the tester and measure its voltage.

These testers have different test socket positions for different LED currents, you would start at the two-mA position and work up. There are a few low-current two-mA LEDs and some 10-mA LEDs, but most are rated at 20 mA. Forward voltage for most red, green, and yellow LEDs is about two volts, but some with that rating have a maximum of three. Blue, white, and a few green LEDs are three to five volts and infrared LEDs are 1.2 to 1.5 volts.

It is easy to build an LED tester using a nine-volt battery and a few resistors. A DIP IC socket makes a good test socket. Forward voltage for most LEDs is about two volts, so the resistor for the two mA position should drop seven volts at two mA, making it 3,500-ohms (the standard value of 3,300 is close enough).

If the LED lights brightly at two mA, it is either a two-mA type or a super bright 20-mA type. (I don't know how to tell the difference, except that if it is two mA and you operate it at 20 mA, it will be very bright, but won't last very long.)

For 10 mA, the resistor is 700 ohms (680 is okay) and for 20 mA, it is 350 ohms (330). A power switch isn't needed, as there is no current unless an LED is connected. Many LEDs have a maximum reverse voltage rating of five volts, but I haven't had any problem with nine volts in the tester for only a few seconds. You could add Zener diodes to limit the reverse voltage, but then a power switch would be needed, as the Zeners would always draw current.

Bill Stiles
Hillsboro, MO

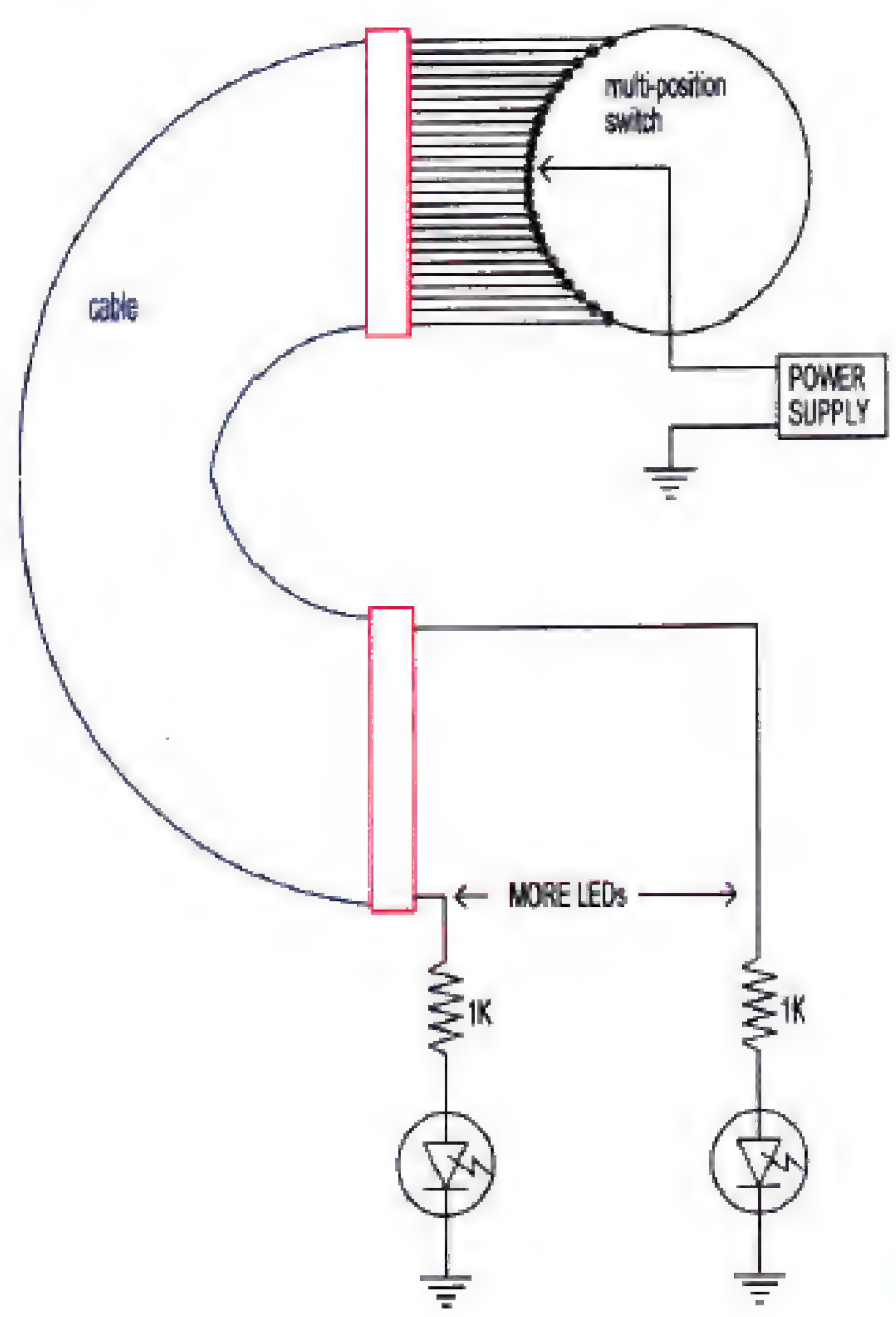
[#2057 - February 2005]

I am looking for a wiring diagram to help me build a cable tester. The cables have between six and 12 wires.

#1 Building a cable tester is a fairly simple job. Check out the schematic at the following link: **http://home.comcast.net/~matt1289/tester.html**

Matt Grasso
via Internet

#2 This is a quick and dirty solution. The LEDs are arranged to



light in sequence as the operator steps through the switch positions. If an LED lights out of sequence, it is incorrectly wired; if more than one LED lights, there is a short. If no LED lights, there is an open. The process could be automated with a microprocessor, but I think that is beyond the scope of this forum.

Russ Kincaid
Milford, NH

#3 Nestor Quiroga might want to check out an article that was published in the July 1997 *Popular Electronics*. It's a DTMF wire tracer. The tracer has a DTMF tone decoder and display on one end and a DTMF encoder with about 10 leads on the transmitter end. You connect the transmitter on the far end to wire pairs — from one to 10 pairs. Then, you go to the other end with the receiver. As you touch the receiver to each wire, the display shows a number from one to 10, corresponding to the wire the transmitter lead is connected to.

I built one of these several years ago. Copies of the article, as well as a PCB set for the project, are still available from FAR CIRCUITS Printed Circuit Boards, 18N640 Field Court, Dundee, IL 60118; (847) 836-9148.

Cost of the PCB set is $9.00. Far Circuits also has a website with the boards listed at **www.farcircuits.net/dtmf1.htm**

E. Kirk Ellis, KI4RK
Pikevill, NC

[#2056 - February 2005]

How can I restrict outgoing calls on my land line from one phone?

#1 Reversing the tip-ring connections to some touch tone phones will prevent the touch tone pad from functioning, but will still allow dial tone, ringing, and incoming calls. Depending on the resourcefulness of the person you are trying to block, reversing the wires behind the wall jack may be a sufficient obstacle.

John Montalbano
via Internet

#2 I assume you want to block users while you are out, but allow *you* to use it when you return. I have used a PIC and a DTMF receiver (M8870-01P) to control activity on a phone line. It would allow long distance only after the correct password was dialed.

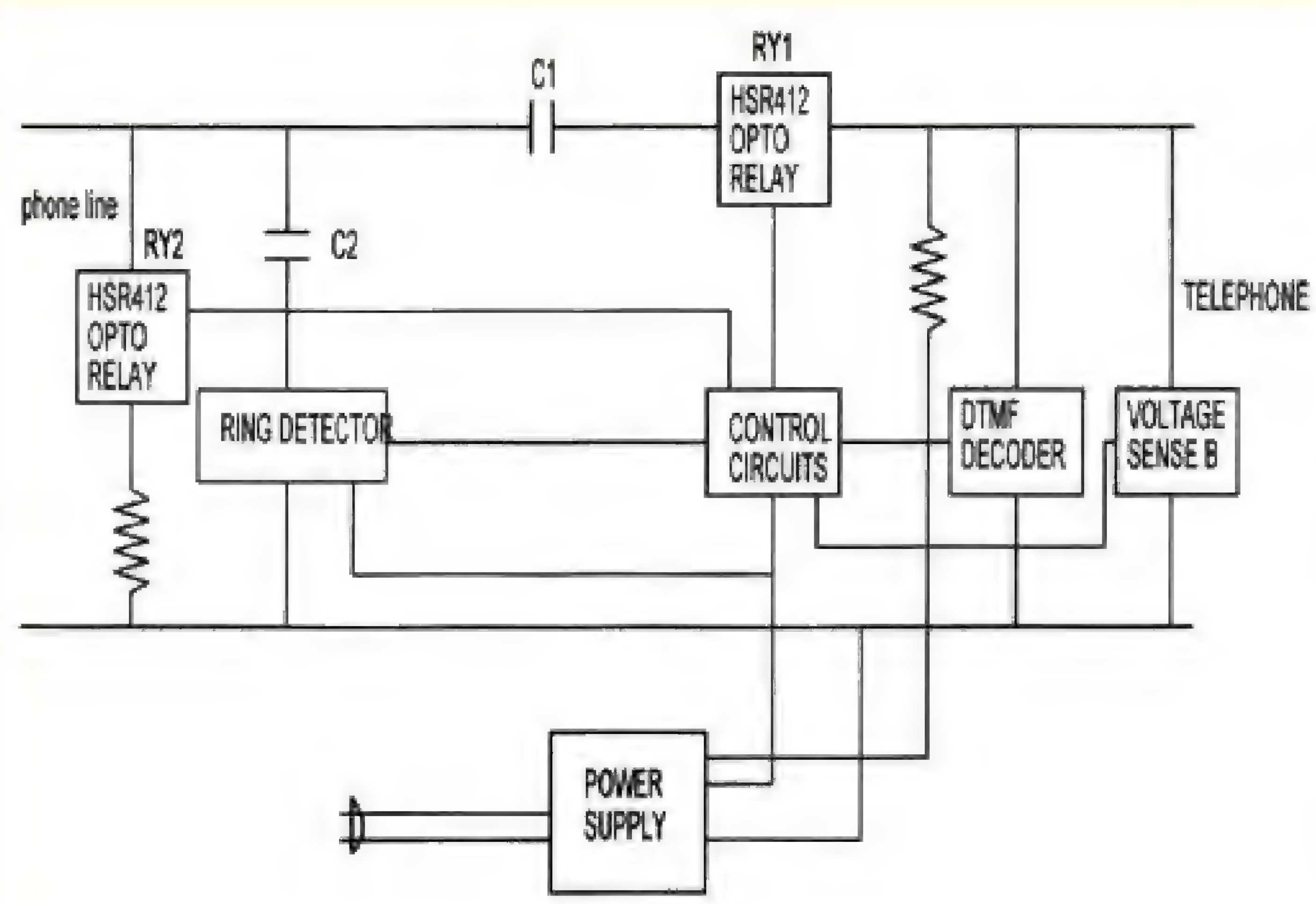
If you want to make it restrict all calls, the code could be modified.

If you are interested, my email is: electronicshobbyshop@cpol.net

Dennis Hewett
Frontenac, KS

#3 This block diagram is my approach to solving your problem. The detail design would be a bit of work. Here is how it works: the ring detector, through the control circuit, turns on RY1, passing the signal on to the telephone. When the handset is lifted, the telephone line voltage drops, the voltage sense turns on RY2, putting a load on the line and "taking the line off hook." This condition remains until the handset is replaced allowing the telephone voltage to rise, which is sensed and turns RY1 and RY2 off.

In order to place a call, the handset is lifted and a code is entered at the keypad. If the code is accepted, both RY1 and RY2 turn on, allowing the dial tone to be heard and a call to be placed. When the handset is replaced, RY1 and RY2 turn off and no call can be placed until the code is entered. C1 separates the line DC and telephone DC; C2 separates the AC ring tone from the line DC.



Russ Kincaid
Milford, NH

[#2058 - February 2005]

What circuitry could I use to determine the winner of a Pine Box Derby race? These little cars cross the finish line at very fast speeds and are usually only milliseconds apart. I would like to use infrared or laser beams to be broken by the cars as the trigger for the circuit to determine the winner.

#1 I designed and built a device which I called the "Pinewood Derby Scoreboard." I wrote an article that was published in the November/December 1985 issue of *Hands-On Electronics*.

The article contains the parts list, schematic, and PC board layouts for the "scoreboard" (double-sided) and the four lane sensors that are at the finish line on the track.

It's admittedly old technology (11 ICs and four LED displays), but I would be happy to have copies of the article made and send them to Mr. Sheetz.

After telling you about the Pinewood Derby Scoreboard that I developed many years ago, I ran across a copy of a circuit that was published in the May 1969 issue of *Popular Electronics*. It uses two phototransistors and a CA3018. I have never tried the circuit. I can copy the schematic and send it along if you desire.

Jack Meagher, W2EHD
Southern Shores, NC

#2 You will find schematics for a Pinewood Derby timer on my website,

www.geocities.com/russlk There are two schematics: a "which came first" circuit that just lights a lamp over the track of the winner and a timer schematic that displays the elapsed time, up to 9.99 seconds.

It has been my experience that kids don't understand the timer; they just want to know who won. Adults can use the timer to eliminate runoffs and save time, but the kids couldn't care less. RadioShack no longer carries the IR sensor that I used, but similar devices are available.

(Note: Geocities does not allow links. You have to put the URL in the address bar.)

Russell Kincaid
Milford, NH

[#03051 - March 2005]

I've been looking for USB logic analyzers and have wondered why I can't just use a USB parallel eight-bit FIFO development module. I don't have a lot of knowledge about the USB world, but I like the price of building my own (if it can be done) instead of the $300.00 plus models on the market. Any ideas would be great.

A USB development module contains a USB controller that can respond only to communications sent to the controller's address on the bus. A USB protocol analyzer must silently capture traffic to and from other devices' addresses. The analyzer then sends the captured data to a PC or logic analyzer, which displays the information in a meaningful format.

Accomplishing all of this is not a simple task! Full-speed USB data travels at 12-Mbits/sec. High speed is 480-Mbits/sec. Besides displaying the raw data, the analyzer's software decodes standard USB requests and status codes and identifies the device and endpoint that is the source or receiver of the data in each transaction.

Prices for protocol analyzers have come down a lot in the last couple of years. Another option is a software-only analyzer, which can't show the same low-level details as a hardware analyzer, but can be less expensive — or even free. I have links to both types of analyzers here: www.Lvr.com/usb.htm.

Jan Axelson
via Internet

[#03052 - March 2005]

I have a new computer running Windows XP. The hard drive partitions work the same as always (fdisk), but I don't know how to set up a dual-boot configuration. As usual, the help files in Windows are useless. How do I teach the new computer to boot in either XP or 98?

I have done this a couple of times

by formatting the hard drive as two FAT32 partitions (FAT32 is not required, but the Windows 98 partition must be either FAT or FAT32 and the XTP partition must be either FAT32 or NTFS), then installing Windows 98. Boot-up the computer (in Windows 98, obviously), then start installing XP from within 98. The software will ask if you want an upgrade or new installation. It will recommend an upgrade.

Choose new installation. (Be careful about the default answers.) One of the choices will be Advanced. If you choose Advanced, it will allow you to put XP in the second partition. Finish the installation. (It will reboot several times.) When finished, the computer will have two partitions — one with Windows 98 and the other with XP. When you boot, you will have several seconds to go to 98 or it will default to XP.

Load any other software in the normal manner, from whichever operating system is appropriate. (If you want to use a program in both places, it will most likely have to be installed from both partitions, unless it is DOS-based.)

George Kaelin
Loogootee, IN

[#03053 - March 2005]

How do I test the condition of the contacts on 24-VDC, 30-amp sealed relays?

Your best bet would be to take an ohm reading of the contacts and subtract it from the resistance when new (that is, if you have that reading). The higher the reading is, the more resistive build-up there is on the contacts, making them not work as well. Hint: To increase the life of the contacts, use a diode across the power pins of the relay to help cut down on sparking (due to the EMF of the coil) and lengthen the life of the contacts.

Calvin Witt (13 years old)
Thousand Oaks, CA

[#03055 - March 2005]

I purchased a desktop telephone with caller ID from Southwestern Bell about five years ago. I have moved several times and lost the wall wart power supply, as well as the instruction manual. The phone itself only shows the polarity, not the voltage or current requirements.

The model number is CT-10. A web search only found a Pantronics wireless headset with that model number. The only other unique number was the Federal Communications Commission (FCC) registration number: 5LRCHN-32708-MT-E.

I looked on the FCC website and found that this phone had been

re-registered on June 3, 1999 and was made by Shenzhen Taifeng Electronic Co., Ltd., for Southwestern Bell and others. I found an address in China for this company, but they never wrote back.

Does anyone have the voltage and current requirements for the power supply for this CT-10 telephone with caller ID?

The easy way to do this is to get one of the multi-voltage adapters available from Wal-Mart, RadioShack, and others. Match the adapter to the phone and match the polarity to the symbol on the phone. Set the voltage to minimum and plug it in. The phone will probably not work. Change the voltage up one setting. Try again.

At some setting, the phone will work and the display will become visible, but dark. Change the voltage up one more setting. This is probably the correct answer, and your phone will work just fine.

If desired, substitute a fixed-voltage adapter that matches that voltage setting. Remember that most of the multi-voltage adapters supply 750 mA or more and be sure that the new adapter has an adequate current rating or the voltage will sag from the marked voltage and not be able to supply the phone.

I have used this trick a number of times with everything from portable radios to laptop computers with universally satisfactory results.

George Kaelin
Loogootee, IN

[#03054 - March 2005]

I have an older ATX motherboard that does not have the BIO's power-on feature — "When AC Power Restored, Boot Up Computer" — on it.

I need some type of circuit that will momentarily make contact with the power-on button when the AC power is applied to the computer.

A simple way to accomplish this is to use a 120-volt A/C to 12-volt DC wall wart, a 12-volt relay, 2.2-kohm resistor, and a 1,000-mf capacitor.

Take the positive 12-volt output of the wall wart and connect it to one side of the relay coil with the other side of the relay coil wired to the positive side of the 1,000-mf capacitor. Wire the negative side of the wall wart output to the negative side of the capacitor and connect the 3.3K ohm resistor across the positive and negative leads of the capacitor. Wire the normally-open contacts of the relay across the power-on button in the PC.

Once power is applied to the wall wart, the relay will engage until the cap charges and then drop out. The

resistor will discharge the capacitor upon power failure and, when the power is restored, the process will be repeated.

The momentary closure of the relay will cause the PC to power-up when power is restored. RadioShack part numbers are as follows:

Wall wart	273-1779
Relay	275-241
Capacitor	272-1019
Resistor	271-1122

Wayne Eckert
Fort Lauderdale, FL

[#03056 - March 2005]

I'm looking for a simple turn signal reminder circuit I can install in a truck that doesn't have self-canceling signals. I would prefer something that could be tied into the flasher circuit. I know one of your older magazines had such a circuit, but I can't find my back issue. Any help would be appreciated.

#1 It can't be any simpler than this, as no "circuit" is required. Just wire (observing proper polarity) a piezo buzzer across the turn signal flasher contacts. The piezo buzzer will sound in unison with the flasher.

RadioShack part #273-060 (85-dB piezo buzzer, 3>28-VDC, 5 mA) is an appropriate unit, but other suppliers — such as All Electronics and Jameco — have similar items. For the RS part (which has thin stranded wire leads), just unplug the flasher, insert (observing proper polarity) the leads in the socket, and reinstall the flasher so that the leads are held firmly.

Ray Mueller
Surf City, NJ

#2 Back in the mid-80s, I was about to patent a turn signal reminder called SIGNALERT. I didn't do so, but I still have several hundred of these units available. They work great and are highly reliable.

They are encapsulated in epoxy and install in less than a minute by simply removing the existing flasher unit, then re-inserting the flasher unit into the module clips and then back into the original flasher socket. The module has a wire clip for attaching it somewhere appropriate under the dashboard where it can be heard, but not seen.

They operate by counting flashes and were calculated to sound-off when an automobile traveled about 1/4 mile at 55 mph with the turn signal still applied. They work only in conjunction with the flasher unit energized so they only draw battery power when a turn-signal is applied, which is really not worth mentioning, since it operates on two CMOS chips and only a few passive components.

If interested, contact me at jfmcomp@localnet.com and I will send you a module.

John F. Mastromoro
St. Johnsville, NY

[#04051 - April 2005]

I am using a variac to control the voltage going to a filament for heating purposes. Does anyone know of a way to control the AC current going to this filament in an electronic fashion?

#1 You didn't provide too much detail about your application, so I'll make a few assumptions along the way. First of all, using a variac to control temperature implies that this is an open-loop system. You, however, "close the loop" by observing the temperature on a thermometer and making small adjustments to the variac, as needed. If the environment is relatively stable, you could develop a calibration table to equate variac knob position with temperature. Of course, if you just turn on power with the variac set at a fixed position, it may take some time to reach a steady-state temperature.

I'm also assuming that you are using conventional wall power (115 VAC) and that the filament load current is around an amp or so.

If this more accurately describes your application, then the simplest solution is to replace the rather bulky (and expensive) variac with a low-cost lamp dimmer control. Get the kind that has a rotary control knob with a push on/off switch.

This way, once you find the proper setting, simply push the switch to turn it on and off. Most lamp dimmers are capable of controlling 300-watt resistive loads and are readily available at hardware and electrical supply stores for less than $10.00.

Heavy-duty dimmers are also available, if your application requires more current. Mount the dimmer in a 4 x 4 metal electrical box, along with a duplex outlet so you can easily plug in your heater.

If you'd like to upgrade to a closed-loop controller, they are also available, but at a much higher cost. The advantage is that the steady-state temperature will be reached quicker and the temperature will be more repeatable and stable over various environmental conditions. Some controllers also have a built-in temperature readout. However, it will require that a thermistor, thermocouple, or probe be placed near the heater to provide an electrical feedback signal to the controller. Search the Internet (and eBay) for "proportional temperature controllers" if you are interested.

I found a "no frills" controller with probe for $55.00 at **http://mcshaneinc.com/html/5CX-140.html**

Bob Kovacs
West Orange, NJ

#2 Power to a resistive load such as yours can be controlled with a three terminal silicon device called a triac. Simply put, one terminal (the gate) receives a setpoint voltage. The other two leads are the input and output and go in series with the load. The gate voltage controls the voltage at which the triac turns on. The triac turns off when the current through it goes to zero (when the AC current wave form changes sign). Therefore, by varying the voltage on the gate, you can vary the percentage of time during the AC cycle that current flows.

This, in turn, varies the power delivered to the load. The web page at **www.electronics-lab.com/projects/motor_light/041/** shows a fairly complicated circuit that uses a triac (Q1) to control power to a load.

You can replace all the fancy electronics with a properly wired and isolated potentiometer. Almost any application note on a triac will include that simplified schematic.

Tom Tillander
Bay Village OH

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CHALLENGE 2:

Dexterity. Stack nine concrete cylinders weighing about 70 pounds each in a 4-3-2 vertical arrangement, but don't knock them over as the pyramid grows! The winner is the competitor who arranges the cylinders in the shortest time.

CHALLENGE 3:

Walking Race. Walk the 100 foot* long U-shaped challenge course, stepping over a small obstacle at the half-way point. The shortest time wins, with a time bonus being granted based on any auxillary load carried. Walking must be powered.

The current rule set is available online at

www.servomagazine.com/tetsujin

and questions can be directed to

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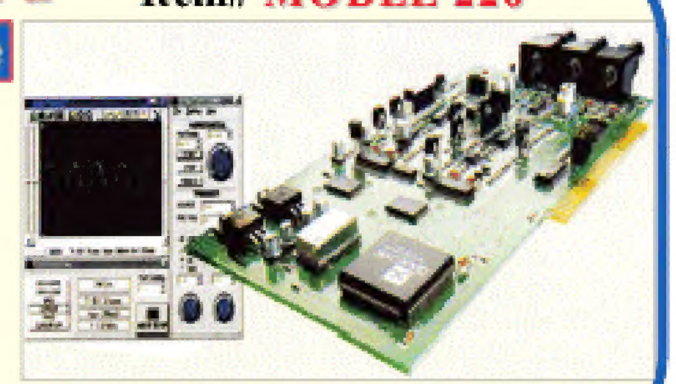

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Both Models have a 1A/5VDC Fixed Output on the rear panel

CSI3003X-5: 0-30v/0-3amp/1-4..$97.00/5+..$93.00

CSI5003X-5: 0-50v/0-3amp/1-4..$107.00/5+..$103.00

Details at Web Site > Test Equipment > Power Supplies

Circuit Specialists, Inc. 220 S. Country Club Dr., Mesa, AZ 85210

800-528-1417 / 480-464-2485 / FAX: 480-464-5824

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3M™ DataCom Cable Tester

UNBEATABLE PRICE

Limited Time Offer

Item# **DT-2000**

This unit allows for mapping, testing and troubleshooting of various lines, including installed data communications, phone wiring and coaxial cable runs. Performs multiple test on the following cable types, up to 1000 feet in length: Unshielded telephone cables with RJ-11 and RJ-45 connectors; Ethernet 10 (100) Base-T; Token Ring; EIA/TIA-568 A/B; AT&T 258a; USOC; 50 or 75 ohm Coax with F or BNC connectors.

Only $49.00

Originally Sold for $200.00!

Details at Web Site — Includes: Holster, Case, 7 Remotes & Telecom Alligator Clips

> **Test Equipment > Specialty Test Equipment**

RF Field Strength Analyzer

Compare at Over $2000!

New Fantastic Low Price: $1299.00!

The **3201** is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2060MHz. The 3201 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones, Cordless phones, paging systems, cable & Satellite TV as well as antenna installations. May also be used to locate hidden cameras using RF transmissions

Item# **3201**

- WFM/NFM/AM/SSB modulated signals may be measured.
- Signal Levels up to 160Channels can be displayed simulaneously on the LCD
- PLL tuning system for precise frequency measurement and tuning
- Built-in Frequency Counter
- LED Backlight LCD (192x192 dots)
- All fuctions are menu selected.
- RS232C with software for PC & printer interface
- Built-in speaker

(Includes Antenna)

Limited Time Offer

Details at Web Site > **Test Equipment > RF Test Equipment**

Flexible Full-Sized Roll-Up Keyboard

This virtually industructable keyboard is ruggedized and can stand all kinds of abuse. It's made of a high quality silicone material which offers the perfect combination of practicality, durability, comfort and flexibility. The unique material allows you not only to clean the keyboard with soap and water, but makes it **resistant to any dirt, dust, sand and even coffee or tea spills!** Simply wipe up the spilled liquid with a damp cloth and continue working.

Only $23.95

Compatible with PS/2 or USB

Details at Web Site > **Personal Computing & Network Products > Keyboards**

Item# **ROLLUPKEYBOARD**

NEW!

50,000 Count High Accuracy DMM

The 50,000 count resolution provides some of the most accurate readings available in a handheld meter. Readings are easily seen on the large LCD display with backlight, but also included is an analog bargraph to provide a graphic of the critical information being displayed. True RMS readings also enhance the accuracy of this meter. An **RS-232** port and software give you the ability to download all your data to a computer for storage and analysis.

NEW!

Item# **CSIMS8218**

Only $189.00

Details at Web Site > **Test Equipment > Digital Multimeters**

LogicPort Logic Analyzer

The LogicPort provides 34 sampled channels including two state-mode clock inputs. It connects to your PC's USB port for ultimate convenience and performance.

$369.00!

- 34 Channels
- 500MHz Timing mode sample rate
- 200MHz State mode sample rate
- Real-time Sample Compression
- Multi-level trigger
- +6V to -6V Adjustable Threshold

NEW!

Item# **LOGICPORT**

Details at Web Site > **Test Equipment > Logic Analyzers**

SONY Super HAD CCD™

equipped camera's feature dramatically improved light sensitivity

SONY Super HAD CCD Color Weatherproof IR Cameras

480 TV Lines Resolution

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 480TV lines
- Built-in Lens: 6mm/F1.5
- S/N Ratio: > 48dB
- Min. Illumination: 0Lux

Item# **VC-827D**

1-4: **$149.00** 5+: **$139.00**

Details at Web Site

> **Miniature Cameras(Board,Bullet,Mini's, B/W, Color)**

SONY Super HAD CCD Color Weatherproof IR Camera

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/4" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Built-in Lens: 4.3mm
- S/N Ratio: > 48dB (AGC OFF)
- Min. Illumination: 0Lux

1-4: **$89.00** 5+: **$79.00**

Item# **VC-819D**

Details at Web Site

> **Miniature Cameras(Board,Bullet,Mini's, B/W, Color)**

NEW!

SONY Super HAD CCD B/W Weatherproof IR Camera

- Day & Night Auto Switch
- Signal System: EIA
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Built-in Lens: 6mm/F1.5
- S/N Ratio: > 48dB
- Min. Illumination: 0Lux

1-4: **$69.00** 5+: **$65.00** Item# **VC-317D**

Details at Web Site

> **Miniature Cameras(Board,Bullit,Mini's)**

SONY Super HAD CCD Color Camera

Item# **VC-805** 1-4: **$69.00** 5+: **$65.00**

- Weather Proof
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Lens: 3.6mm
- S/N Ratio: > 48dB
- Min. Illumination: 1Lux/F1.2

Unbelievable Price!

Details at Web Site

> **Miniature Cameras(Board,Bullit,Mini's)**

SONY Super HAD CCD Mini B/W Board Camera

Item# **VC-103**

- Signal System: EIA
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV Lines
- Lens: 3.6mm/92° Angle of View
- Min. Illumination: .05Lux/F1.2

1-4: **$33.00** 5+: **$29.00**

Details at Web Site

> **Miniature Cameras**

Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ www.CircuitSpecialists.com. PC based data acquisition, industrial computers, loads of test equipment, optics, I.C's, transistors, diodes, resistors, potentiometers, motion control products, capacitors, miniature observation cameras, panel meters, chemicals for electronics, do it yourself printed circuit supplies for PCB fabrication, educational D.I.Y. kits, cooling fans, heat shrink, cable ties & other wire handleing items, hand tools for electronics, breadboards, trainers, programmers & much much more! ***Some Deals you won't believe!***

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